~~ME 1776~~
ME 1677

SERVICE MANUAL

CATERPILLAR®

D398, G398, D379 AND G379 ENGINES

SERIAL NUMBERS 66B, 67B, 68B, 69B,
72B, 73B, 75B AND 76B

CATERPILLAR TRACTOR CO. PEORIA, ILLINOIS, U.S.A.

SERVICE MANUAL

for

CATERPILLAR®

D398 · G398 · D379 · G379
ENGINES

SERIAL NUMBERS 66B1-UP, 67B1-UP, 68B1-UP, 69B1-UP,
75B1-UP AND 76B1-UP

NOTE: The use of the explanatory information — "☐Remove" and "◗Disconnect" — below each illustration is being discontinued. The symbols, which appear in some groups and not in others, are explained in the Service Manual General Instructions, Group 1A-5-30.

Caterpillar Tractor Co., General Offices, Peoria, Illinois. • Caterpillar Americas Co., Peoria, Illinois. • Caterpillar Overseas S.A., Geneva. • Caterpillar of Australia Pty. Ltd., Melbourne. • Caterpillar Brasil S.A., São Paulo. • Caterpillar Tractor Co. Ltd., Glasgow. • Caterpillar of Canada Ltd., Toronto. • Caterpillar France S.A., Grenoble. • Caterpillar (Africa) (Pty.) Ltd., Johannesburg. • Caterpillar Mexicana S.A. de C.V., Monterrey.

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General Instructions

These general instructions will be extremely helpful in following the detailed instructions in the manual. They should be read and kept in mind while assembling or disassembling the machine.

SYMBOLS

Throughout this Service Manual, symbols are used on the illustrations to point out parts which are to be removed or disconnected. These removals or disconnections are indicated by the following code:

☐ **Remove** ◗ **Disconnect**

The part to be removed or disconnected is pointed out by a number in the symbol and this number corresponds to the part description listed in the caption copy beneath the picture. The disconnect arrow points as close as possible to point of disconnection.

SAFETY AND WORKMANSHIP SUGGESTIONS

There are certain practices which should be followed in the interest of safety and good workmanship when working around machinery.

Always show proper respect for weight. Do not attempt to lift heavy parts when a hoist should be used. Never leave heavy parts in an unstable position. When raising a portion of a machine, be sure the machine is blocked securely at front and rear. The weight should be supported by blocks rather than lifting equipment.

When using a hoist, follow the recommendations outlined in the manual. Fabricate and use the illustrated lifting devices in conjunction with the hoist to achieve the proper balance of the assemblies being lifted and to assure safe handling. (See special topic, GENERAL INSTRUCTIONS, DIESEL ENGINE REMOVAL).

Tools

All service tools should be kept in first-class condition. Use the proper tool for the job at hand. Special service tools are available for specific jobs and should be used when recommended. The use of these tools will save time and prevent damage to parts.

In the manual, puller arrangements are illustrated for separating tightly fitted parts. However, if the machine is being reconditioned in a shop, it might be easier and faster to use a press. When pulling a bearing or gear from a shaft, always use a centering spacer between the forcing screw and end of shaft.

Disassembly

If a part offers unexpected resistance to removal, check carefully to see that all nuts and bolts have been removed before using force. Possibly some other part is interfering and should be removed first. Parts which are fitted together with tapered splines are always very tight. If they are not tight when disassembled, inspect the tapered splines and discard the part if the splines are worn.

Identical parts should be kept in order or marked so they can be reinstalled in the same position from which they were removed.

When shims are used, be sure to remove all of them. Tie the shims together and identify them as to their location. Keep them clean and flat until they are reinstalled.

INSPECT FREQUENTLY AND CORRECT MINOR TROUBLES

A bearing changed in time will save a shaft. An oil leak, corrected, prevents loss of lubricant and an overheated bearing. A nut tightened in time will prevent the loss or breakage of an associated part.

MAINTAIN ADJUSTMENTS

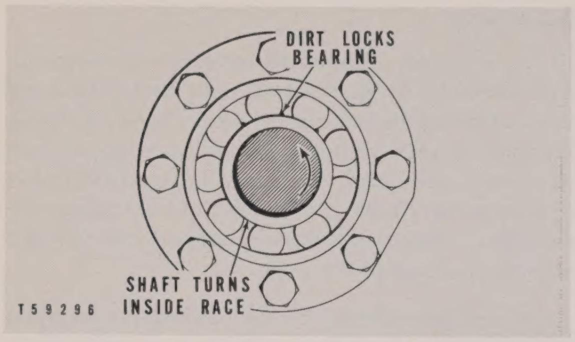
Operating adjustments have been kept to a minimum on Caterpillar-built machines but they are important and should be carefully maintained.

Follow the recommendations in the Operation and Maintenance Instructions.

KEEP DIRT OUT

The most important single item in preserving the long life of the machine is to keep dirt out of vital working parts. Caterpillar Tractor Co. has taken precautions to safeguard against dirt entering working parts. Enclosed compartments, seals and filters have been provided to keep the supply of air, and lubricants clean. It is important that the effectiveness of these safeguards be maintained. Filters should be replaced or cleaned regularly. Worn seals or broken gaskets should be replaced immediately. Be sure seal lips are facing in the correct direction.

Anti-friction bearings, properly lubricated with clean lubricant, will last indefinitely. Abrasives in the lubricant will cause rapid wear on the extremely hard races and balls or rollers. Dirt in an anti-friction bearing can cause the bearing to lock resulting in the shaft turning in the inner race or the outer race turning within the cage. Dirt and abrasives in lubricants will embed in sleeve bearings and act like fine sandpaper against the shaft causing extremely rapid wear.



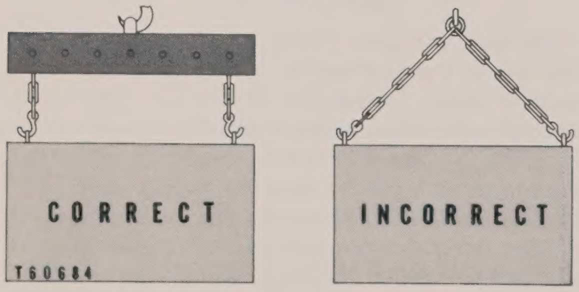
EFFECT OF DIRT IN BEARING

Lubricant must be changed at recommended intervals. Use clean containers. Before removing the filler cap, brush away the dirt.

Whenever hydraulic, fuel, lubricating oil, air or brake lines are to be disconnected, clean the point of disconnection as well as the adjacent area. As soon as a disconnection is made, cap, plug or tape the line or opening to prevent entry of foreign material. The same recommendations for cleaning and covering apply when access covers or inspection plates are removed.

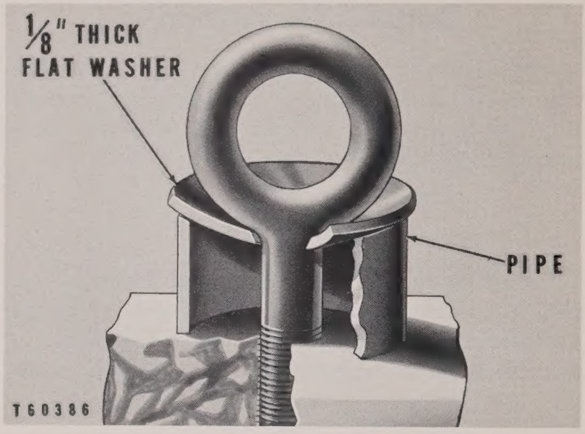
DIESEL ENGINE REMOVAL

Unless otherwise specified, all engine removals should be accomplished using an adjustable lifting beam. For maximum efficiency of the lifting apparatus, all supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the cylinder head. See the illustration.



LIFTING ENGINE

In cases where it is necessary to remove the engine on an angle, it must be remembered that the lifting capacity of the lifting eyes on the engine diminishes as the angle between the supporting members and cylinder head becomes less than 90°. Lifting eyes and brackets should never be bent and should only have stress in tension. A length of pipe and a washer can be utilized, as shown, to help relieve these stresses on lifting eyes.



LIFTING EYE

CLEANING AND INSPECTION

Clean all parts thoroughly after they are removed and inspect them. Be sure all lubricant passages and oil holes are open. Badly worn or damaged parts should not be reinstalled on the machine. Cover all parts to keep them clean until they are installed and leave the new parts in the container.

Anti-friction bearings should receive special handling. As soon as a bearing is removed, cover it to keep dirt and abrasives out. Wash bearings in nonflammable cleaning solution and allow bearings to drain dry. Do not blow dry with air pressure or spin the bearings. Inspect the races and balls or rollers. Discard the bearings if they are pitted, scored or burned. If the bearing is serviceable, coat it with light oil and wrap it in clean paper. Do not unwrap new bearings until time of installation.

Replace all damaged O-rings and gaskets. In some assemblies and systems, it is recommended that O-rings be replaced when components are being reassembled.

Inspect parts carefully. Refer to the topic, SPECIFICATIONS, as a guide for parts replacement.

SPECIFICATIONS

The manual SPECIFICATIONS sections contain dimensions for new parts and a suggested guide for amount of wear that might normally be considered a reasonable figure to use in determining when to replace parts. These wear dimensions are shown after the description, "permissible clearance". The specifications are provided to help determine when new parts should be installed. This information should not be regarded as the only factor in determining when to replace parts. Past performance should be the governing factor for part replacement. Even though parts are worn they may still be satisfactory. The remaining service life of these parts must be considered when deciding if parts should be replaced. If a machine is disassembled for reconditioning, it is well to replace parts not completely worn out if the remaining service life is deemed short.

ASSEMBLY

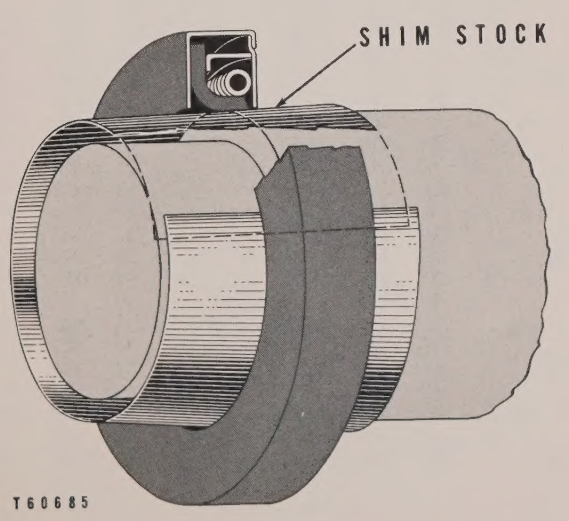
Clean the rust preventive compound from all machined surfaces of new parts before installing them. Be sure to install parts in the proper location and position.

Bearings which have a shrink fit should be heated in oil not to exceed 250° Fahrenheit, before attempting to install them. Other parts which require a shrink fit can be heated to a higher temperature in an electric oven or by other suitable means, but not to exceed a temperature which would remove hardness.

Parts which are heated to facilitate assembly must sometimes be allowed to cool and then pressed together again. Often the parts will separate as they cool and shrink.

When one part is pressed into another, use white lead or a suitable prepared compound to lubricate the mating surfaces. Tapered parts, however, should be assembled dry. Before assembling parts with tapered splines be sure the splines are clean, dry and free from burrs. Then press the parts together tightly.

When installing new bearings or reinstalling used bearings, lubricate the bearings liberally. Bearings that are to be preloaded must have a liberal film of oil over the entire assembly before the preloading procedure is carried out.



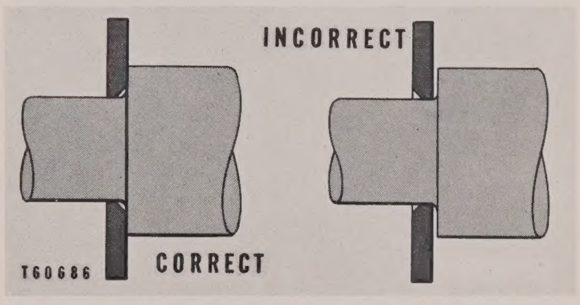
PROTECTING SEAL DURING INSTALLATION

Lubricant should be applied to the lip of all lip-type rubber seals before installation. This will prevent damage to the seal during the initial running until the oil being sealed has contacted the sealing face. Apply lubricant to an O-ring seal before installation to prevent rolling and twisting of the seal.

Silicone seals are subject to swelling when cleansed or immersed in kerosene or diesel fuel.

Packing-type seals should always be renewed if the contacting part is removed.

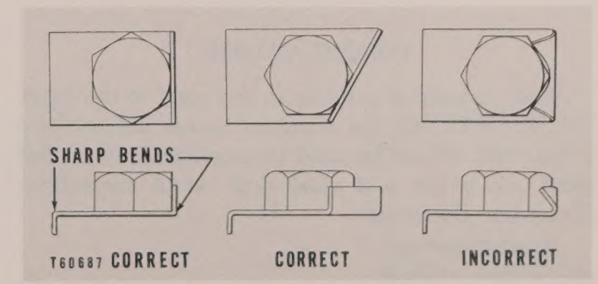
When installing a bearing, spacer or washer against a shoulder on a shaft, be sure the chamfered side is toward the shoulder. If the washer is turned in the wrong direction the radius may interfere and prevent washer from seating against the shoulder.



HOW TO INSTALL SPACER AGAINST SHOULDER ON SHAFT

Do not install sleeve bearings by driving them in with a hammer. Use a press if possible and be sure to apply the pressure directly in line with the bore. If a bearing must be driven in, use a bearing driver or a bar with a smooth flat end. If the sleeve bearing has an oil hole, be sure it is aligned with the oil hole in the part into which it is assembled.

Install gaskets where required and use new ones if necessary. Never use cork or felt gaskets or seals a second time. Be sure the holes in the gaskets correspond with the lubricant passages in the mating parts. If it is necessary to make gaskets, select stock of the proper type and thickness and be sure to cut sufficient holes in the right places. Blank gaskets can cause serious damage.

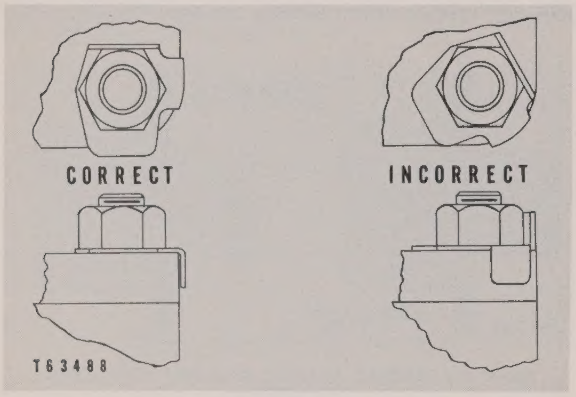


HOW TO INSTALL FLAT METAL LOCKS

Use bolts of the correct length. A bolt which is too long may "bottom" before the head is tight against the part it is to hold, and in addition the threads may be damaged when the bolt is removed.

If a bolt is too short, there may not be enough threads to hold the part securely.

Lockwashers, cotter pins or flat metal locks should be used to lock each nut and bolt. Flat metal locks must be installed properly to be effective. Bend one end of the lock sharply around the edge of the part. Bend the other end sharply against one flat surface of the nut or bolt head. Do not bend the lock against more than one side of the nut.



METHOD FOR LOCK POSITIONING AND BENDING

When assembling a machine, complete each step in turn. Do not leave one part partially assembled and start assembling some other part. Make all adjustments as recommended. Always check the job after it is completed to see that nothing has been overlooked.

PREPARATION FOR STARTING

After assembling a machine, lubricate it thoroughly. Fill the various compartments with the type and grade of lubricant recommended in the Operation and Maintenance Instructions.

Recheck the various adjustments by operating the machine before returning it to the job.

TORQUE VALUES

Unless reference is made in the copy to the topic, SPECIFICATIONS, the standard torque values listed in the chart should be used for standard heat-treated bolts and studs and steel nuts when assembling Caterpillar Equipment.

GENERAL USAGE

(Tightening Torques)

SIZE (NC and NF)	TORQUE (Pound Feet)	SIZE (NC and NF)	TORQUE (Pound Feet)
1/4"	6-12	3/4"	230-300
5/16"	13-23	7/8"	360-480
3/8"	27-37	1"	560-720
7/16"	40-60	1 1/8"	700-900
1/2"	65-85	1 1/4"	880-1120
9/16"	95-125	1 3/8"	1050-1350
5/8"	130-170	1 1/2"	1300-1700

HYDRAULIC VALVE BODIES

(Tightening Torques)

SIZE (NC and NF)	TORQUE (Pound Feet)
5/16"	13-17
3/8"	24-30
7/16"	39-47
1/2"	60-70
5/8"	118-142

DECIMAL EQUIVALENTS

The decimal dimensioning system provides a more accurate means of specifying dimensions and tolerances .The following table includes the standard conversions from fractions to decimals. Decimals are shown in the standard two, three and four place designation.

1/64	.02	.016	.0156	33/64	.52	.516	.5156
1/32	.03	.031	.0312	17/32	.53	.531	.5312
3/64	.05	.047	.0469	35/64	.55	.547	.5469
1/16	.06	.062	.0625	9/16	.56	.562	.5625
5/64	.08	.078	.0781	37/64	.58	.578	.5781
3/32	.09	.094	.0938	19/32	.59	.594	.5938
	.10				.60		
7/64	.11	.109	.1094	39/64	.61	.609	.6094
1/8	.12	.125	.1250	5/8	.62	.625	.6250
9/64	.14	.141	.1406	41/64	.64	.641	.6406
5/32	.16	.156	.1562	21/32	.66	.656	.6562
11/64	.17	.172	.1719	43/64	.67	.672	.6719
3/16	.19	.188	.1875	11/16	.69	.688	.6875
13/64	.20	.203	.2031	45/64	.70	.703	.7031
7/32	.22	.219	.2188	23/32	.72	.719	.7188
15/64	.23	.234	.2344	47/64	.73	.734	.7344
1/4	.25	.250	.2500	3/4	.75	.750	.7500
17/64	.27	.266	.2656	49/64	.77	.766	.7656
9/32	.28	.281	.2812	25/32	.78	.781	.7812
19/64	.30	.297	.2969	51/64	.80	.797	.7969
5/16	.31	.312	.3125	13/16	.81	.812	.8125
21/64	.33	.328	.3281	53/64	.83	.828	.8281
11/32	.34	.344	.3438	27/32	.84	.844	.8438
23/64	.36	.359	.3594	55/64	.86	.859	.8594
3/8	.38	.375	.3750	7/8	.88	.875	.8750
25/64	.39	.391	.3906	57/64	.89	.891	.8906
	.40				.90		
13/32	.41	.406	.4062	29/32	.91	.906	.9062
27/64	.42	.422	.4219	59/64	.92	.922	.9219
7/16	.44	.438	.4375	15/16	.94	.938	.9375
29/64	.45	.453	.4531	61/64	.95	.953	.9531
15/32	.47	.469	.4688	31/32	.97	.969	.9688
31/64	.48	.484	.4844	63/64	.98	.984	.9844
1/2	.50	.500	.5000	1	1.00	1.000	1.0000

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ENGINE
SPECIFICATIONS

See the SPECIFICATIONS, in the GENERAL INSTRUCTIONS.

Number of cylinders:

D379 and G379	8
D398 and G398	12
Bore and stroke	6¼″ x 8″

Firing order:

D379	
Counterclockwise	1-8-5-4-7-2-3-6
Clockwise	1-4-5-2-7-6-3-8
D398	
Counterclockwise	1-12-9-4-5-8-11-2-3-10-7-6
Clockwise	1-4-9-8-5-2-11-10-3-6-7-12

Balancer Gears (D379 and G379 Only)

Shaft diameter	1.5996 - 1.6000 in.
Bearing bore	1.6019 - 1.6025 in.
Bearing clearance	.0019 - .0029 in.
Permissible bearing clearance	.006 in.
End clearance	.0060 - .0135 in.
Permissible end clearance	.019 in.

Camshaft

Bearing journal diameter	2.9660 - 2.9670 in.
Bearing clearance	.002 - .006 in.
Permissible bearing clearance	.009 in.
End clearance	.006 - .010 in.
Permissible end clearance	.020 in.
Gear retaining bolts, torque	60 - 70 lb. ft.
Backlash between camshaft gear and crankshaft gear	.003 - .005 in.

Connecting rod

Connecting rod bearing clearance	.0043 - .0072 in.
Permissible bearing clearance	.012 in.
Center-to-center distance	17.9990 - 18.0010 in.
Bore in piston pin bearing	2.4510 - 2.4516 in.
Connecting rod bolt nuts, torque	250 lb. ft.
Side end clearance	.012 - .021 in.

Crankshaft

Main journal diameter	5.7490 - 5.7500 in.
Main bearing clearance	.005 - .008 in.
Permissible bearing clearance	.015 in.
End clearance	.008 - .021 in.
Permissible end clearance	.035 in.
Main bearing stud nuts, torque	675 - 825 lb. ft.
Connecting rod journal diameter	4.9990 - 5.0000 in.
Permissible journal wear	.010 in.
Permissible out-of-roundness (journal)	.006 in.

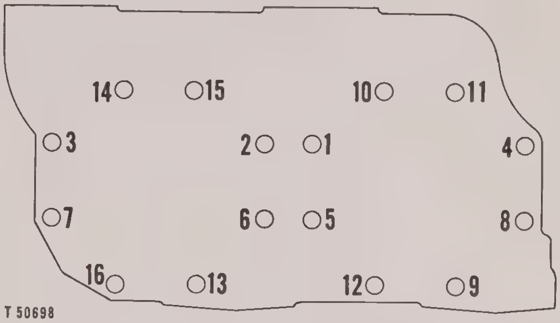
Cylinder Block

Main bearing original bore dimension	6.3720 - 6.3730 in.

Cylinder Head

Tighten nuts in sequence shown in illustration

Initial	150 lb. ft.
Final	250 lb. ft.



CYLINDER HEAD STUD NUT TIGHTENING SEQUENCE

Cylinder Liner (Use 6H4141 Adapter Plate for Removal)

Inside diameter	6.250 - 6.251 in.
Permissible liner wear (increase in diameter at top of ring travel)	.020 in.
Counterbore dimension in block	.498 - .500 in.
Liner flange thickness	.504 - .506 in.

Flywheel

Run-out:	
Permissible at outside diameter	.006 in.
Permissible at face	.002 in.
Retaining bolts, torque	345 - 405 lb. ft.

Flywheel Housing

Retaining bolts, torque	
Inside housing	118 - 142 lb. ft.
All others	60 - 70 lb. ft.

Front Accessory Drive

Main idler shaft diameter	2.9960 - 2.9970 in.
Main idler bearing bore	3.000 - 3.001 in.
Main idler bearing clearance	.0035 - .0055 in.
Permissible bearing clearance	.010 in.
Small idler gear shaft diameter (two)	1.9975 - 1.9985 in.
Small idler gear bearing bore (two)	2.000 - 2.001 in.
Small idler bearing clearance (two)	.0015 - .0035 in.
Permissible bearing clearance	.008 in.
End clearance, all idlers	.003 - .009 in.
Permissible end clearance	.018 in.

Fuel Injection Equipment

Fuel injection pump timing (before top center)	12°
Fuel injection pump lifter setting (on engine with piston at top dead center)	2.0860 - 2.0940 in.
Fuel injection pump lifter setting (off engine)	2.1555 - 2.1575 in.
Fuel pump plunger length	2.9831 - 2.9837 in.
Permissible wear (decrease in length of plunger)	.005 in.
Injection nozzle orifice (Use 8M4813 Drill for cleaning)	.038 in.
Fuel injection camshaft bearing bore	2.4450 - 2.4460 in.
Bearing clearance	.002 - .003 in.
Permissible bearing clearance	.006 in.

LIFTER SETTING IN DEGREES (OFF ENGINE)

Lifter No. (numbered consecutively front to rear)	Timing Plate Degrees D379*		Timing Plate Degrees D398*	
	Counter-clockwise	Clockwise	Counter-clockwise	Clockwise
1	0°	12°	0°	12°
2	210°	222°	210°	222°
3	270°	102°	240°	132°
4	120°	312°	90°	342°
5	90°	282°	120°	252°
6	300°	132°	330°	102°
7	180°	192°	300°	72°
8	30°	42°	150°	282°
9	—	—	60°	312°
10	—	—	270°	162°
11	—	—	180°	192°
12	—	—	30°	42°

*Timing Plate must be rotated in the same direction as arrow on camshaft.

Rack shaft diameter	.609 - .610 in.
Rack bearing clearance	.0014 - .0040 in.
Permissible bearing clearance	.006 in.
Injection valve retaining nut torque	100 - 110 lb. ft.

Fuel Injection Pump and Governor Drive Shaft

Bearing bore:	
Inner	1.9265 - 1.9285 in.
Outer	1.6250 - 1.6260 in.
Bearing clearance:	
Inner	.001 - .004 in.
Outer	.0015 - .0035 in.
Permissible bearing clearance	.009 in.
End clearance	.005 - .008 in.
Permissible end clearance	.015 in.
Backlash between drive gear and driven gear	.004 - .009 in.

Fuel Transfer Pump

Clearance between gears and covers	.0010 - .0024 in.
Bearing bore	.4950 - .4954 in.
Bearing clearance	.001 - .002 in.
Permissible bearing clearance	.005 in.

Generator

	12V - 35A DR1105148	32V - 60A DR1117074
Brush spring tension	28 oz.	13 oz.
Rotation (viewing drive end)	Clockwise	Clockwise
Circuit	A	B
Field current (80°F.): Volts Amps	 12 1.54 - 1.67	 32 2.2 - 2.5
Output (cold): Volts Amps Approximate RPM	 14 35 1950	 37.5 51* 2500

*Output at given speed. Rated hot output 60 Amps.

Generator Regulator (12V-35A—Delco-Remy 1119002-E)

Circuit	A
Polarity	Negative ground
Cut-out relay:	
Armature-yoke air gap	.020 in.
Point opening	.020 in.
Closing voltage range	11.8 - 13.5
Voltage regulator:	
Armature-yoke air gap	.060 in.
Voltage setting range (85°F.)	14.2 - 15.2
Current regulator:	
Armature-yoke air gap	.075 in.
Current setting range	34.0 - 38.5

Generator Regulator* (32V-60A—Delco-Remy 9000557)

Circuit	B
Polarity	Negative ground
Voltage regulator voltage setting	37.5

*This transistor regulator does not have cutout and current regulator settings.

Governor

Backlash between drive gear and driven gear	.002 - .006 in.
Bearing clearance	.002 - .003 in.
Permissible bearing clearance	.008 in.

Natural Gas Models

Backlash between bevel gear and magneto drive pinion	.002 - .006 in.
Direction of magneto rotation (G379 and G398)	clockwise
Impulse coupling nut torque (American Bosch Magneto)	20 lb. ft.
Magneto contact point clearance	.017 in.
Spark plug gap	.013 in.
Spark plug torque	30 lb. ft.
Spark plug adapter torque:	
Steel	225 lb ft.
Brass	150 lb. ft.
Timing:	
Natural gas (methane—dry):	
10:1 compression ratio NA* (before top center)	25°
10:1 compression ratio TA* (before top center)	17½°**
7:1 compression ratio NA* (before top center)	30°
7:1 compression ratio TA* (before top center)	30°***
Wet natural gas or butane:	
7:1 compression ratio NA* (before top center)	20°
Propane:	
10:1 compression ratio NA* (before top center)	12½°
Line pressure regulator differential pressure (value A) in inches of water:	
(Earlier with Ensign Carburetor)	7 - 10
(Later with Impco Carburetor)	5½

*NA—Naturally Aspirated
TA—Turbocharged and Aftercooled

**90° maximum temperature of water to the aftercooler

***130° maximum temperature of water to the aftercooler

Oil Pump (Single-section)

Clearance between gears and end covers	.0049 - .0065 in.
Drive shaft journal diameter:	
Outer	1.2486 - 1.2492 in.
Inner	1.6147 - 1.6153 in.
Drive shaft bearing clearance	.0020 - .0040 in.
Permissible bearing clearance	.008 in.
Idler shaft diameter	1.3742 - 1.3748 in.
Idler gear bearing clearance	.0014 - .0030 in.
Permissible bearing clearance	.006 in.

Oil Pump (Two-section)

Main pump:	
Clearance between gears and end covers	.0049 - .0065 in.
Scavenge pump:	
Clearance between gears and end covers	.0045 - .0065 in.
Drive shaft journal diameter:	
Outer (two)	1.2686 - 1.2691 in.
Inner	1.6147 - 1.6153 in.
Drive shaft bearing clearance:	
Outer (two)	.0014 - .0040 in.
Inner	.0024 - .0040 in.
Permissible bearing clearance	.008 in.
Idler shaft diameter	1.3742 - 1.3748 in.
Idler gear bearing bore	1.3756 - 1.3766 in.
Idler gear bearing clearance	.0008 - .0024 in.

Piston Pins

Clearance in rod bearing	.0010 - .0019 in.
Permissible clearance in rod	.006 in.
Clearance in piston	.0004 - .0010 in.
Permissible clearance in piston	.006 in.

Piston Rings

Piston ring side clearance:	
Top ring	.0050 - .0062 in.
Intermediate ring	.0030 - .0046 in.
Oil control ring	.0015 - .0031 in.
Permissible clearance (top compression ring)	.012 in.
Ring gap:	
Top ring	.025 - .034 in.
Intermediate ring	.023 - .036 in.
Oil control ring	.017 - .030 in.

Precombustion Chamber

Torque	225 lb. ft.

Rocker Arm Bearings

Shaft diameter	1.2230 - 1.2240 in.
Bearing bore	1.2255 - 1.2265 in.
Bearing clearance	.0015 - .0035 in.
Permissible bearing clearance	.009 in.

Service Meter

Bearing bore diameter	.5555 - .5565 in.
Permissible bearing clearance	.012 in.

Throwers (Crankshaft)

Location front (tight against shoulder on crankshaft)	
Location rear (tight against shoulder on crankshaft)	
Permissible run-out on thrower ring groove face (both)	.006 in.
Oil ring side clearance:	
Front	.0035 - .0040 in.
Rear	.0035 - .0040 in.

Turbocharger (Schwitzer 4D)

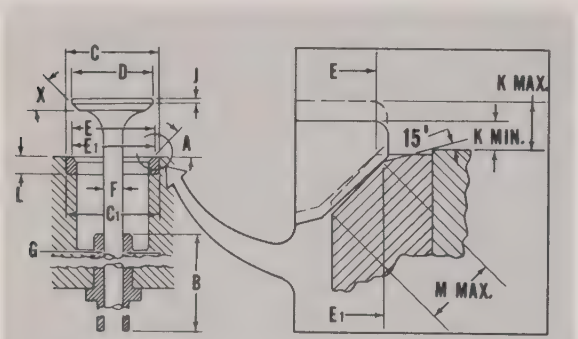
Torque on turbine housing and compressor housing band clamp bolts	10 lb. ft.
Torque on compressor back plate-to-bearing housing bolts	17 lb. ft.
Torque on impeller nut (cold)	30 lb. ft.
Clearance between impeller and compressor back plate (Shaft pushed toward impeller end)	.020 - .022 in.
End clearance	.004 - .006 in.
Permissible end clearance	.008 in.
Bearing diameter (ID)	.6880 - .6883 in.
Bearing diameter (OD)	1.0585 - 1.0590 in.
Permissible bearing clearance (satisfactory if compressor wheel and/or turbine wheel have not rubbed housing or housings)	
Journal diameter	.6820 - .6865 in.
Housing bore diameter	1.0625 - 1.0630 in.
Thickness of thrust bearing	.025 - .026 in.
Thickness of thrust rings	.099 - .100 in.
Width of groove in sleeve	.128 - .130 in.
Side clearance in groove of sleeve with two piston rings installed	.002 - .006 in.
Minimum piston ring width	.062 in.
Maximum piston ring groove width (turbine)	.068 in.
Mounting bolt (turbocharger-to-manifold)	36 - 44 lb. ft.

Turbocharger (Schwitzer — 4HD755 and 4HD854)

Torque values:	
Compressor cover band clamp bolts	120 lb. in.
Turbine housing to bearing housing bolts	17 lb. ft.
Impeller nut (cold)	30 lb. ft.
Thrust bearing retaining bolts	60 lb. in.
Turbocharger mounting bolts	36 - 44 lb. ft.
Clearance between impeller and bearing housing	.018 - .022 in.
End clearance	.004 - .006 in.
Permissible end clearance	.008 in.
Bearing diameter (ID)	.6880 - .6883 in.
Bearing diameter (OD)	1.0585 - 1.0590 in.
Permissible bearing clearance (Satisfactory if compressor wheel and/or turbine wheel have not rubbed cover or housing).	
Journal diameter	.6862 - .6865 in.
Housing bore diameter	1.0625 - 1.0630 in
Thickness of thrust bearing	.225 - .226 in
Thickness of thrust rings	.099 - .100 in.
Width of groove in sleeve	.128 - .130 in.

Side clearance in groove of sleeve with two ring seals installed side by side .... .002 - .006 in.
Minimum ring seal width .... .062 in.
Maximum ring seal groove width .... .068 in.

Valve and Valve Seat Specifications



VALVE AND VALVE SEAT SPECIFICATIONS

A–Valve seat angle. B–Valve guide length. C–Valve seat insert diameter. C_1–Bore for valve seat insert. D–Valve head diameter. E–Outside diameter of valve seat face (new). E_1–Outside diameter of valve seat face [After reconditioning (MAX.)]. F–Stem diameter. G–Valve guide bore. J–Valve lip thickness. K–Measurement from top of valve to face of head with valve seated. L–Depth of bore for valve seat inserts. M–Valve seat width. X–Valve face angle.

T72421

	INLET	EXHAUST
A	30°	30°
B	5.062″	5.438″
C	2.5895″ - 2.5905″	2.4345″ - 2.4355″
C_1	2.586″ - 2.587″	2.431″ - 2.432″
D	2.500″ - 2.510″	2.345″ - 2.355″
E	2.457″	2.302″
E_1	2.480″ MAX.	2.325″ MAX.
F	.4950″ - .4960″	.4950″ - .4960″
*G	Earlier .499″ - .500″ Later .4985″ - .5005″	Earlier .499″ - .500″ Later .5000″ - .5020″
J	.140″ MIN.	.124″ MIN.
K	.119″ MIN. - .165″ MAX.	.104″ MIN. - .165″ MAX.
L	.6355″ - .6375″	.6355″ - .6375″
†M	.073″ MAX.	.072″ MAX.
X	29¼°	29¼°

*Measure valve guide bore in portion of guide which is pressed into cylinder head closest to valve head.

†If valve seat face exceeds the maximum width after grinding, narrow the seat face by using a 15° stone or fly cutter.

Maximum permissible valve stem clearance in valve guide Inlet .009 in.
Exhaust .009 in.

Valves

Compression release clearance (distance between rocker arm and lifter rod) .... .025 - .030 in.
Exhaust valves:
Clearance (cold) .... .035 in.
Inlet valves:
Clearance (cold) .... .015 in.

Valve Lifters

Lifter diameter .... .9960 - .9970 in.
Bearing bore .... .9990 - 1.0000 in.
Clearance between lifter and bore .... .002 - .004 in.
Permissible clearance .... .010 in.

Valve Springs

Outer:
Pounds force .... 50 - 55
When compressed to .... 1.953 in.
Inner:
Pounds force .... 27 - 30
When compressed to .... 1.922 in.

Valve Timing

With valve clearances set correctly, dial indicator mounted above valve stem, reading taken with valve .075″ off seat:
Exhaust opening (before bottom center) .... 30° 30′
Exhaust closing (before top center) .... 1° 15′
Inlet opening (after top center) .... 4° 15′
Inlet closing (after bottom center) .... 14° 0′

Vibration Damper (D398 and G398 Only)

Adapter to crankshaft bolt torque .... 345 - 405 lb. ft.
Damper to adapter bolt torque .... 210 - 250 lb. ft.

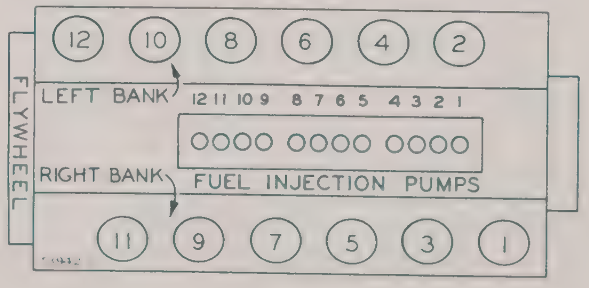
Water Pump (Fresh and Raw Water)

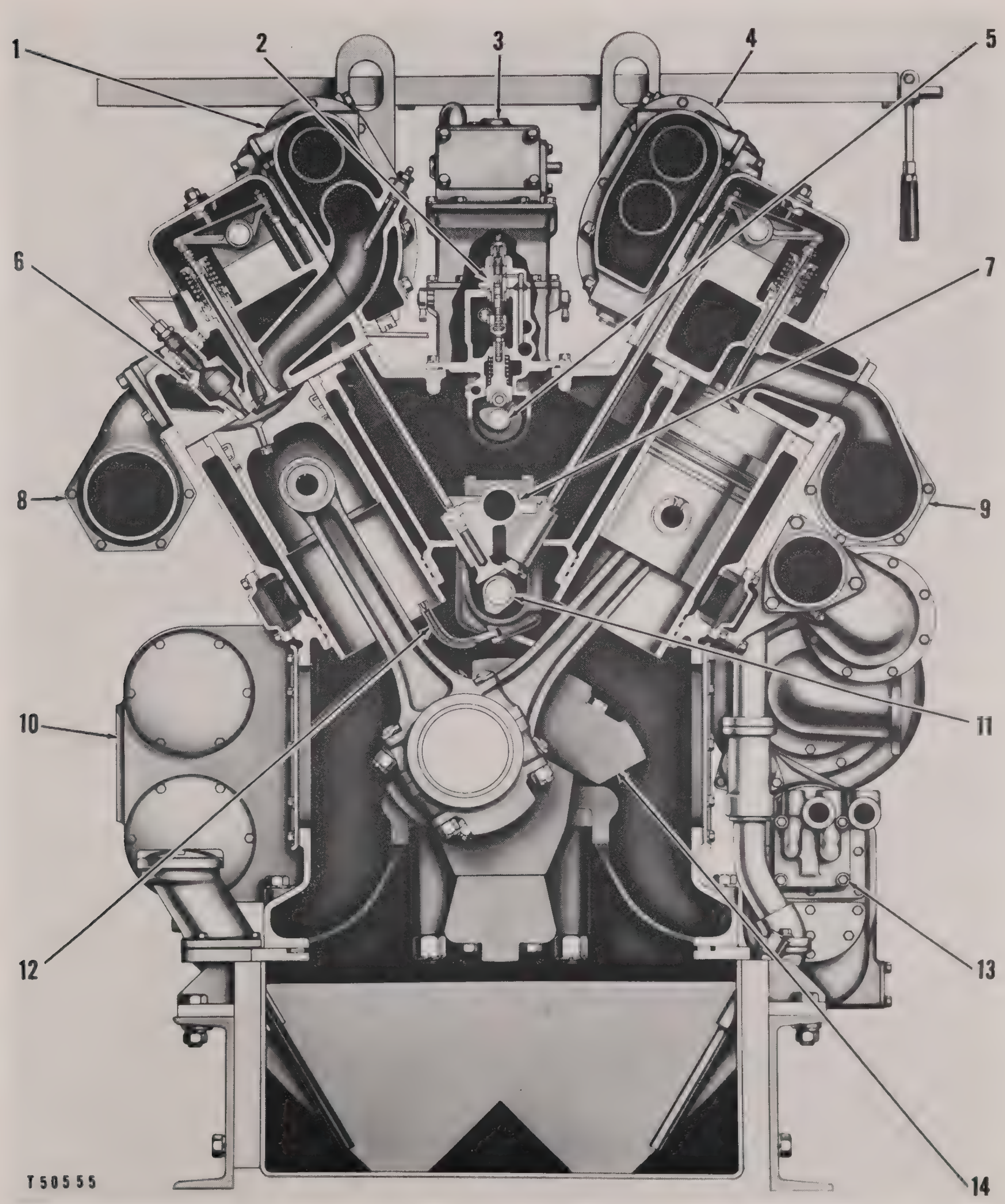
Bearing bore .... 1.248 - 1.249 in.
Bearing clearance .... .002 - .004 in.
Permissible bearing clearance .... .008 in.
Shaft end clearance .... .002 - .004 in.
Clearance between impeller and cover .... .005 - .020 in.
Impeller retaining nut torque .... 55 lb. ft.

Water Temperature Regulator

Opening temperature for testing .... 164° - 166° F.
Fully open temperature for testing .... Approximately 180° F.

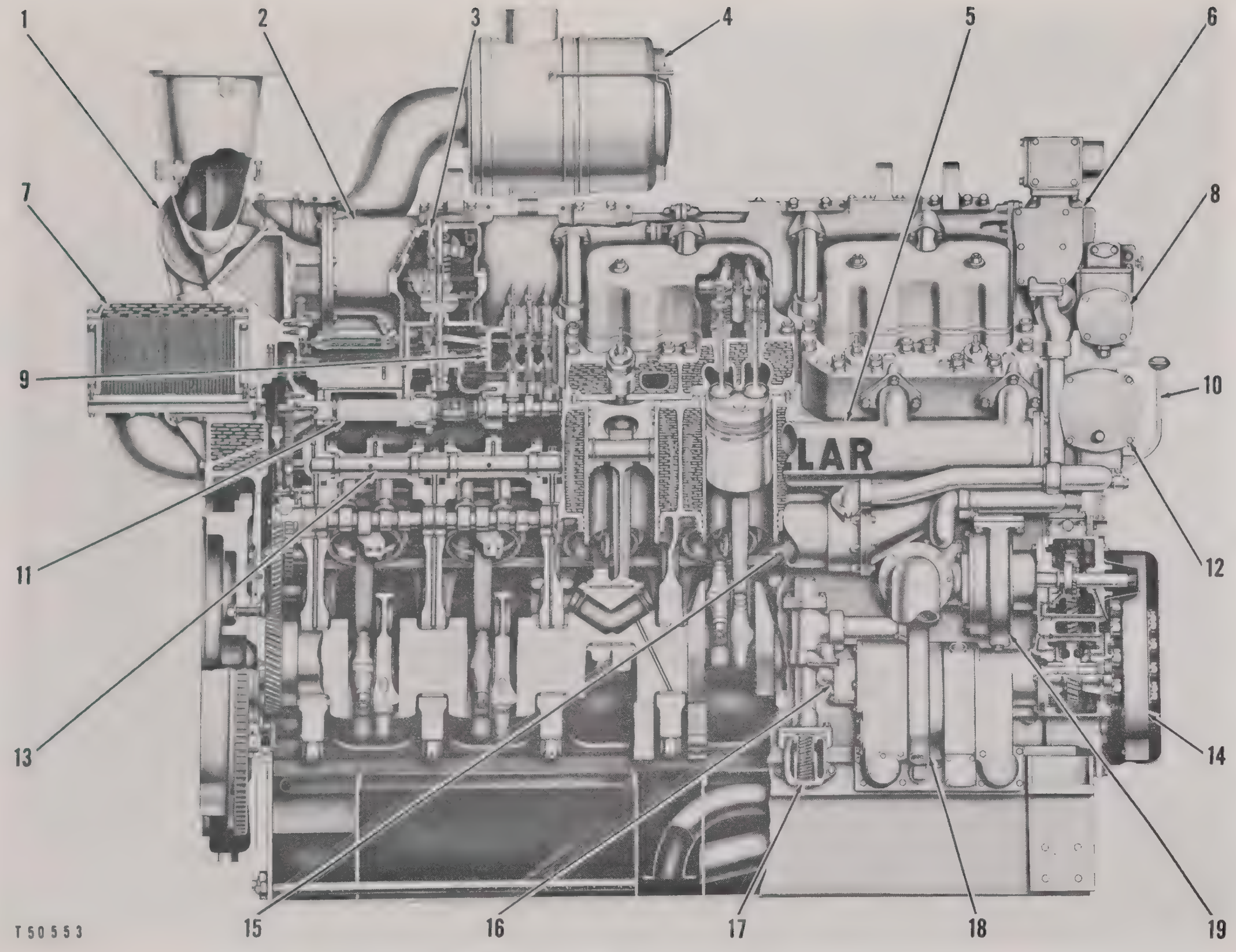
The following illustration shows the numbering of the cylinders and fuel injection pumps (12 cylinder engine illustrated — 8 cylinder engine numbered in similar sequence).





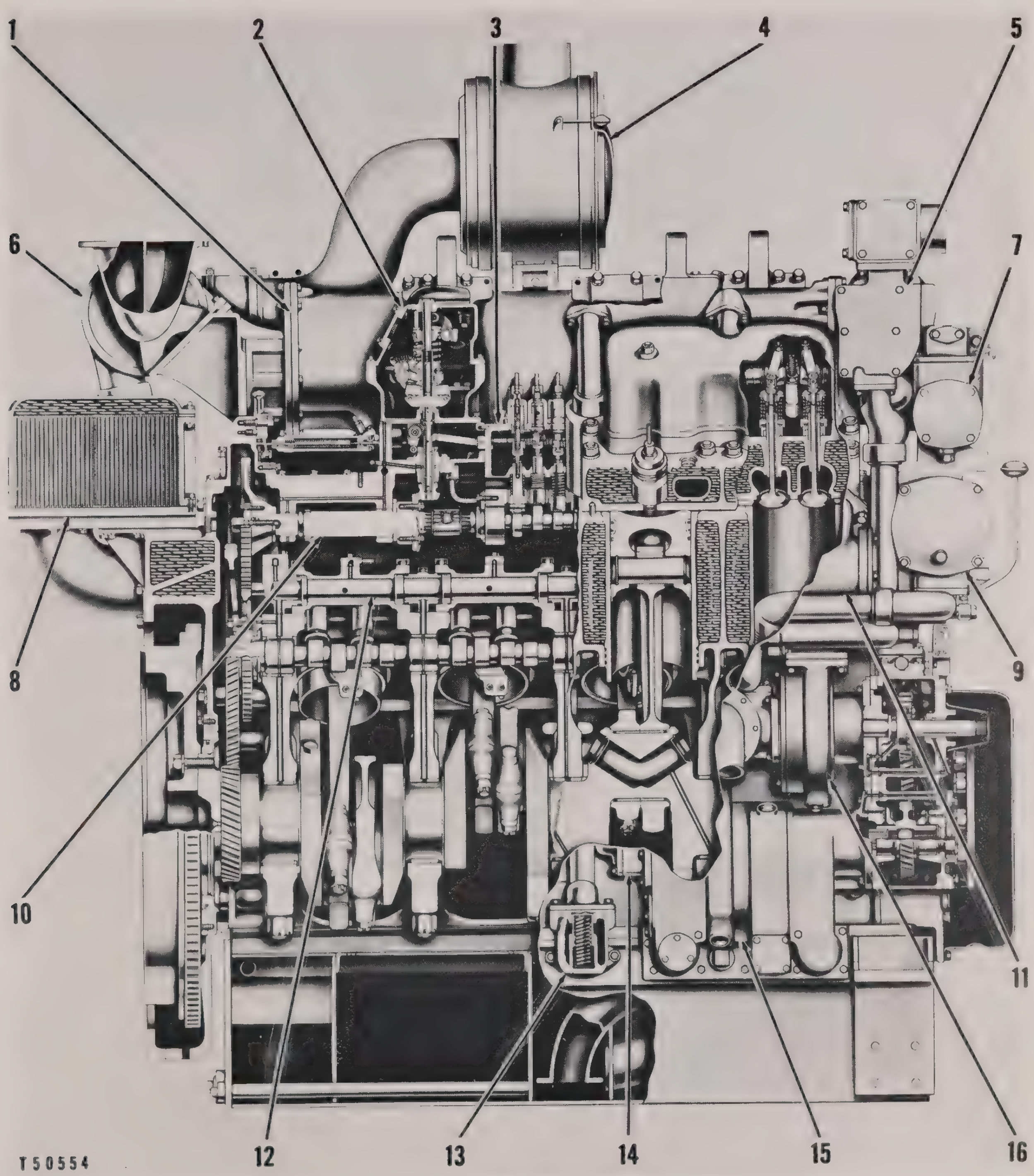
REAR VIEW (CUTAWAY)

1–Left bank exhaust manifold.
2–Fuel injection pump.
3–Governor.
4–Right bank exhaust manifold.
5–Fuel injection pump camshaft.
6–Precombustion chamber.
7–Oil distribution manifold.
8–Left bank inlet manifold.
9–Right bank inlet manifold.
10–Front accessory drive housing.
11–Camshaft.
12–Oil spray tube (one per cylinder).
13–Fuel transfer pump.
14–Crankshaft counterweight.



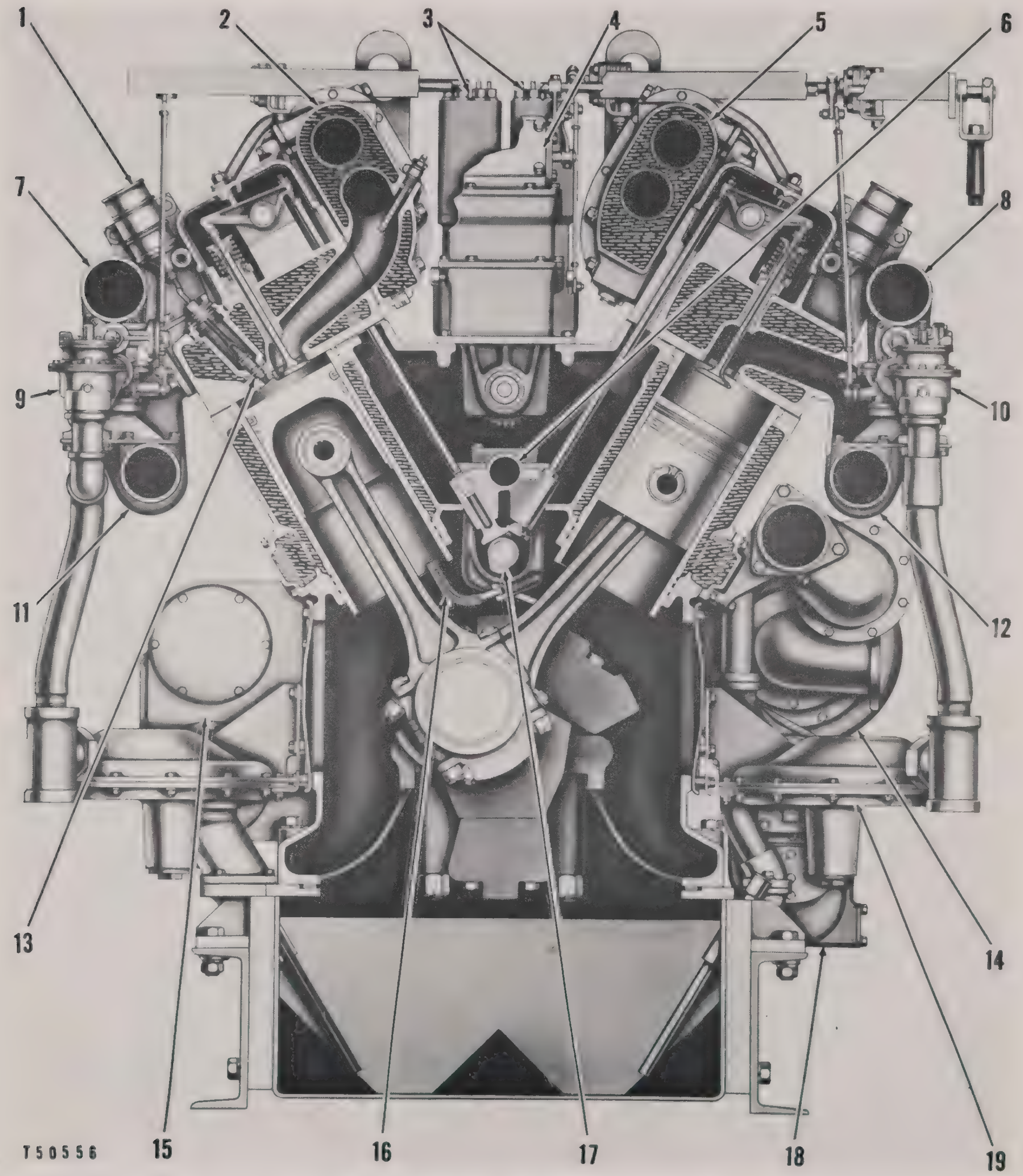
D398 — RIGHT SIDE VIEW (CUTAWAY)

1–Turbocharger (two).
2–Exhaust manifold (two).
3–Governor.
4–Air cleaner (two).
5–Inlet manifold (two).
6–Water temperature regulator housing (two).
7–Aftercooler.
8–Fuel filter.
9–Fuel injection pump housing.
10–Fuel priming pump lever.
11–Fuel pump and governor drive shaft.
12–Oil filter.
13–Oil distribution manifold.
14–Vibration damper.
15–Oil cooler.
16–Fuel transfer pump.
17–Oil pressure regulating valve.
18–Oil pump.
19–Water pump.



D379 — RIGHT SIDE VIEW (CUTAWAY)

1–Exhaust manifold (two).
2–Governor.
3–Fuel injection pump housing.
4–Air cleaner (two).
5–Water temperature regulator housing (two).
6–Turbocharger (two).
7–Fuel filter.
8–Aftercooler.
9–Oil filter.
10–Fuel pump and governor drive shaft.
11–Inlet manifold (two).
12–Oil distribution manifold.
13–Oil pressure regulating valve.
14–Fuel transfer pump.
15–Oil pump.
16–Water pump.



NATURAL GAS ENGINE — REAR VIEW (CUTAWAY)

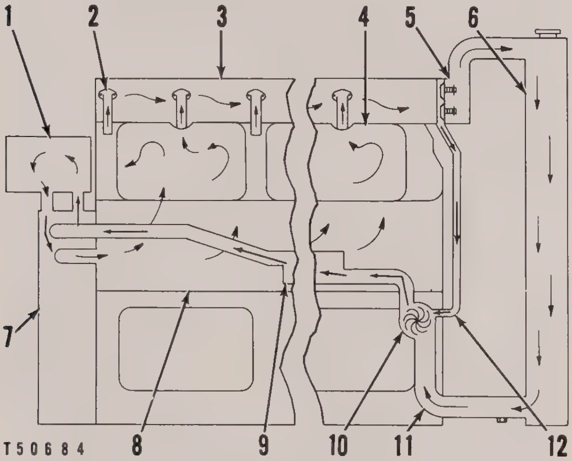
1–Ignition coil (one per cylinder).
2–Left bank exhaust manifold.
3–Magnetos.
4–Governor.
5–Right bank exhaust manifold.
6–Oil distribution manifold.
7–Left bank carburetor.
8–Right bank carburetor.
9–Left bank carburetor gas regulator.
10–Right bank carburetor gas regulator.
11–Left bank intake manifold.
12–Right bank intake manifold.
13–Spark plug.
14–Water pump.
15–Front accessory drive.
16–Oil spray tube.
17–Camshaft.
18–Oil pump.
19–Line pressure gas regulator (two–not necessary on all installations).

Cooling System

(Radiator)

A centrifugal-type pump **(10)** is mounted on the right side of the engine on the rear face of the accessory drive housing. An extension of the water pump shaft through the accessory drive housing provides a convenient auxiliary drive. The water pump is gear driven.

The water pump inlet pipe **(11)** is connected to the lower outlet of the radiator **(6)**. Coolant from the pump flows first through the heat exchanger-type oil cooler **(9)** to the top portion of the flywheel housing **(7)**.

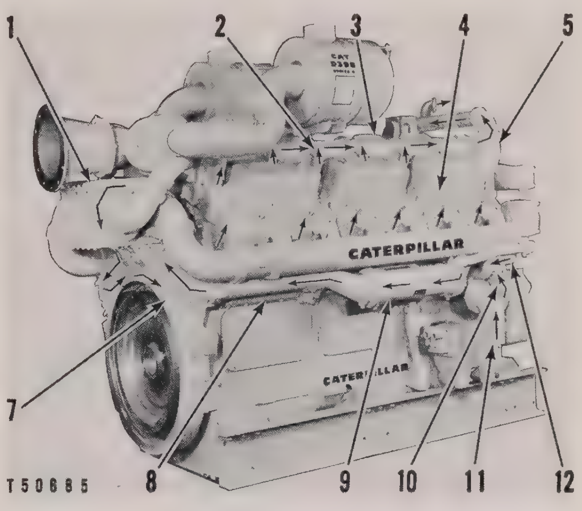


FLOW OF COOLANT (SCHEMATIC)
1–Aftercooler. 2–Elbow. 3–Exhaust manifold. 4–Cylinder head. 5–Temperature regulator housing. 6–Radiator. 7–Flywheel housing. 8–Cylinder block. 9–Oil cooler. 10–Water pump. 11–Inlet pipe. 12–By-pass line.

The flywheel housing has two separate passages. As coolant enters the upper passage, a baffle, formed from sheet metal and bolted to the inlet side of the aftercooler mounting bracket on the flywheel housing, restricts the flow of coolant through the upper passage of the flywheel housing and directs part of the coolant up through the aftercooler **(1)**. The remaining coolant flows across the flywheel housing where it is joined by the coolant returning from the aftercooler.

At the left side of the flywheel housing, the coolant makes a 180° turn and flows back across the flywheel housing through the lower passage where the flow of coolant is divided, part to each cylinder bank of the engine block **(8)**. The coolant then circulates through the cylinder block, around the cylinder liners and upward through the cylinder heads **(4)**.

The coolant flows from the cylinder heads, through the elbows **(2)** to the exhaust manifold **(3)**. The coolant circulates completely around the exhaust manifold and forward to the temperature regulator housings **(5)** at the front of each exhaust manifold.



FLOW OF COOLANT
1–Aftercooler. 2–Elbow. 3–Exhaust manifold. 4–Cylinder head. 5–Temperature regualtor housing. 7–Flywheel housing. 8–Cylinder block. 9–Oil cooler. 10–Water pump. 11–Inlet pipe. 12–By-pass line.

Two regulators, positioned in each housing, control the openings to the radiator to regulate the temperature in the cooling system. Coolant can be directed to the radiator from either the left or right regulator housing or from both sides. When the flow is from only one side a crossover tube connects the two housings.

A by-pass line **(12)** extends from the inlet side of the temperature regulator housings to the inlet side of the water pump. When the temperature of the coolant is not high enough to open the regulators, coolant by-passes the radiator to circulate through engine, assuring quick warm-ups. A portion of the coolant flows through the by-pass line at all times.

OVERHEATING

If difficulty is experienced with the engine overheating, check the following possible causes:

1. Coolant Level.

   Insufficient water in the cooling system. If the water level has been allowed to fall so low that the water is no longer circulating, the engine should be stopped immediately and allowed to cool before adding water. If there is still good circulation, add makeup water slowly while the engine is running. These precautions will minimize the possibility of cracking of the cylinder heads.

2. Fan.
   Loose fan belts.

3. Radiator Clogging — (External)
   Accumulation of leaves, mud and debris around the radiator core. In some cases, these accumulations can be removed by flushing with water or compressed air from the back of the radiator. It may become necessary, eventually, to remove the radiator guard to clean the cores effectively.

4. Water Temperature Regulators.
   Failure of water temperature regulators to open. Check the regulators for opening temperature as described in the topic, TESTING TEMPERATURE REGULATOR. Observe the amount of scale deposited on the regulator. Too much scale will obstruct operation. The engine should not be operated with the regulator removed.

5. Water Pump.
   A badly corroded or worn water pump impeller or impeller loose on the shaft.

6. Internal Clogging.
   Excessive scale or sediment deposits in the radiator, cylinder head or block. Such deposits can cause serious damage to the engine, by retarding the transfer of heat from the head and cylinders to the coolant. In such cases, the water temperature may not be above normal. However, loose scale and sediment may deposit in water passages to such an extent that circulation will be retarded, in which case the water temperature may go above normal.

   To check for lime and scale in the cooling system, remove one of the precombustion chambers and inspect the surface which comes in contact with the coolant. To remove hard scale, follow the directions in accordance with the Operation and Maintenance Instructions.

7. Continuous Overload.
   Operating an engine at a continuous overload, which lugs the engine speed down below its rated speed, may also cause overheating. As a correction, the load on the engine should be reduced.

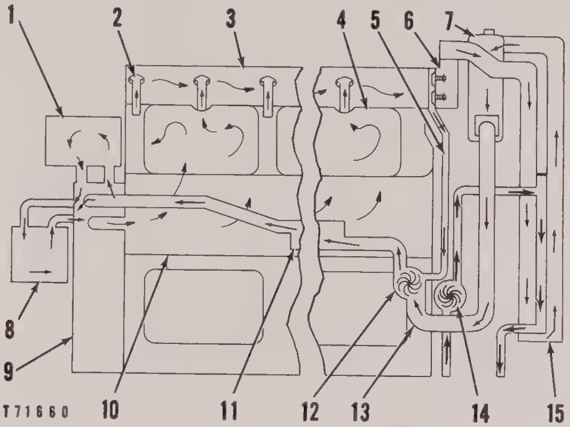
8 Altitude.
   The altitude at which the engine is operating should be considered when overheating is encountered. The horsepower of the engine is decreased as the altitude increases. Also, the boiling point of water is lower at higher altitudes.

9 Water Temperature Indicator.
   It may be that the indicator is not registering correctly. If the indicator is suspected of giving a false reading, install a new one and check the reading.

10. Overheating can also be caused by combustion gases escaping by the precombustion chamber gaskets or cylinder head gaskets and water ferrules and seals. The gases can accumulate in the cylinder head and block, thus restricting the flow of coolant through the cooling system. Thus, the coolant temperature rises rapidly and hot spots will exist in the cylinder head. The easiest method of checking for this condition is to carefully remove the radiator cap and check for air bubbles in the radiator. If air bubbles are present in the cooling system, check the precombustion chambers for tightness and, if necessary, replace the gaskets.

Cooling System
(Heat Exchanger-Cooled)

The coolant is circulated by the water pump **(12)** through the heat exchanger-type oil cooler **(11)** to the top portion of the flywheel housing **(9)**.



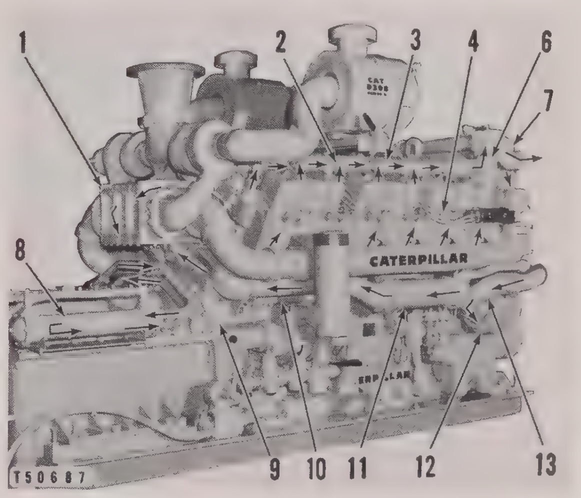
FLOW OF COOLANT (SCHEMATIC)

1–Aftercooler.
2–Elbow.
3–Exhaust manifold.
4–Cylinder head.
5–By-pass line.
6–Temperature regulator housing.
7–Expansion tank.
8–Marine gear oil cooler.
9–Flywheel housing.
10–Cylinder block.
11–Oil cooler.
12–Water pump.
13–Inlet line.
14–Raw water pump.
15–Heat exchanger.

The flywheel housing has two separate passages. As coolant enters the upper passage, a baffle, formed from sheet metal and bolted to the inlet side of the aftercooler bracket on the flywheel housing, extends into the passage to restrict the flow of coolant and direct part of the coolant through the aftercooler **(1)**. The remaining coolant flows across the flywheel housing where it is joined by the coolant returning from the aftercooler. On engines equipped with raw water cooled aftercoolers, the baffle is removed and all of the coolant flows across the flywheel housing.

At the left side of the flywheel housing, the coolant turns 180° and flows back across the flywheel housing through the lower passage where the flow is divided, an equal part going to each bank of cylinders of the cylinder block. On engines equipped with attachments that have heat exchanger-type oil coolers such as a marine gear oil cooler **(8)**, an adapter is attached to the left side of the flywheel housing. Part of the coolant flows through the cooler and is then directed back to the lower passage of the flywheel housing and then directed to the cylinder banks on each side of the cylinder block **(10)**.

The coolant then circulates through the cylinder block, around the cylinder liners and upward through the cylinder heads **(4)**. The coolant flows from the cylinders heads, through elbows **(2)** to the exhaust manifolds **(3)**. The coolant circulates completely around the exhaust manifold and forward to the temperature regulator housings **(6)** at the front of each exhaust manifold.



FLOW OF COOLANT
(D398 Illustrated)

1–Aftercooler.
2–Elbows.
3–Exhaust manifold.
4–Cylinder heads.
6–Temperature regulator housings.
7–Expansion tank.
8–Marine gear oil cooler.
9–Flywheel housing.
10–Cylinder block.
11–Oil cooler.
12–Water pump.
13–Inlet pipe.

Two regulators positioned in each regulator housing, control the flow of coolant to the heat exchanger **(15)** thus controlling the temperature of the engine coolant. The regulator housings are connected by a crossover tube. The coolant flows through the heat exchanger to the expansion tank **(7)**. The inlet pipe **(13)** of the water pump is connected to the expansion tank.

Raw water is pumped by a raw water pump **(14)** through the heat exchanger **(15)** and then through the raw water aftercooler when so equipped. The raw water pump is mounted on the front of the accessory drive housing on the left side of the engine.

A by-pass line **(5)** extends from the inlet side of the temperature regulator housing to the inlet side of the water pump. When the temperature of the coolant is not high enough to open the regulators, coolant by-passes the heat exchanger to assure quick warm-ups. A portion of the coolant flows through the by-pass line at all times.

OVERHEATING

If difficulty is experienced with the engine overheating, check the following possible causes:

1 Coolant Level.

Insufficient coolant in the cooling system. If the coolant level has been allowed to fall so low that the coolant is no longer properly circulating, the engine should be stopped immediately and allowed to cool before adding coolant. If there is still good circulation, add make-up coolant slowly while the engine is running. These precautions will minimize the possibility of cracking the cylinder heads.

2. Raw Water.

Insufficient raw water. Excessive scale or sediment deposits in the inlet and outlet lines will reduce the amount of raw water available to cool the engine coolant. Partially closed valves will also restrict the flow of raw water to the heat exchanger.

3. Water Temperature Regulators.

Failure of water temperature regulators to open. Check the regulators for opening temperature as described in the topic, TESTING TEMPERATURE REGULATORS. Observe the amount of scale deposited on the regulators. Too much scale will obstruct operation. The engine should not be operated with the regulators removed.

4. Water Pump.

A badly corroded, worn or loose water pump impeller.

5. Raw Water Pump.

A badly corroded pump body or worn water pump impeller.

6. Internal Clogging.

Excessive scale or sediment deposits in the heat exchanger, cylinder head or block. Such deposits can cause serious damage to the engine, by retarding the transfer of heat from the head and cylinders to the coolant. In such cases, the water temperature may not be above normal. However, loose scale and sediment may deposit in water passages to such an extent that circulation will be retarded, in which case the water temperature may go above normal.

To check for lime and scale in the cooling system, remove one of the precombustion chambers and inspect the surface which comes in contact with the coolant. To remove hard scale, follow the directions in accordance with the Operation and Maintenance Instructions.

7 Continuous Overload.

Operating an engine at a continuous overload, which lugs the engine speed down below its rated speed, may also cause overheating. As a correction, the load should be reduced to allow the engine to operate at rated speed.

8. Altitude.

The altitude at which the engine is operating should be considered when operating is encountered. The horsepower of the engine is decreased as the altitude increases. Also, the boiling point of water is lower at higher altitudes.

9. Water Temperature Indicator.

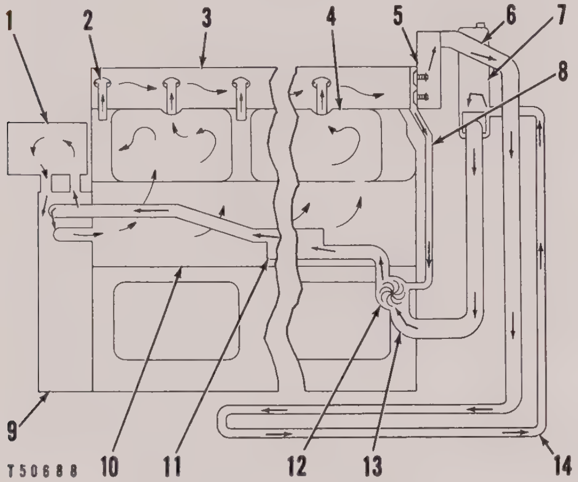
It may be that the indicator is not registering correctly. If the indicator is suspected of giving a false reading, install a new one and check the reading.

10. Overheating can also be caused by combustion gases escaping by the precombustion chamber gaskets, or, cylinder head gaskets and water ferrules and seals. The gases can accumulate in the cylinder head and block, thus restricting the flow of coolant through the cooling system. Thus, the coolant temperature rises rapidly and hot spots will exist in the cylinder head. The easiest method of checking for this condition is to carefully remove the filler cap and check for air bubbles. If air bubbles are present in the cooling system, check the precombustion chambers for tightness and, if necessary, replace the gaskets.

Cooling System

(Keel Cooling)

The coolant is circulated by the water pump **(12)** through the heat exchanger-type oil cooler **(11)** to the top portion of the flywheel housing **(9)**.



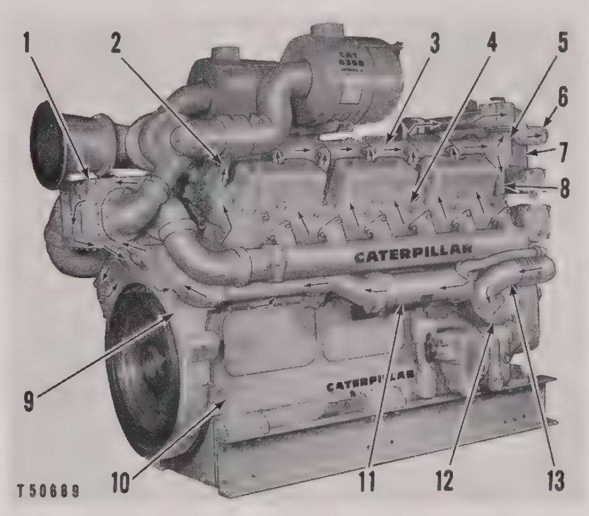
FLOW OF COOLANT (SCHEMATIC)
1–Aftercooler. 2–Elbow. 3–Exhaust manifold. 4–Cylinder head. 5–Temperature regulator housing. 6–Outlet pipe. 7–Expansion tank. 8–By-pass line. 9–Flywheel housing. 10–Cylinder block. 11–Oil cooler. 12–Water pump. 13–Inlet pipe. 14–Keel cooler.

The flywheel housing has two separate passages. As coolant enters the upper passage, a baffle directs part of the coolant up through the aftercooler **(1)**. The remaining coolant flows across the flywheel housing where it is joined by the coolant returning from the aftercooler. On engines equipped with a raw-water cooled aftercooler, the baffle is removed and all the coolant flows across the flywheel housing.

At the left of the flywheel housing, the coolant makes a 180° turn and flows back across the flywheel housing through the lower passage. On engines with an attachment, such as a marine gear, where an oil cooler is used, an adapter is mounted on the left of the flywheel housing. Part of the coolant is directed to the oil cooler from the upper passage, passes through the attachment oil cooler and joins the flow of coolant in the lower passage of the flywheel housing.

In the lower passage of the flywheel housing the flow of coolant is divided to each bank of the cylinder block **(10)** where it circulates upward around the cylinder liners, through the cylinder block to the cylinder heads **(4)**.

The coolant flows from the cylinder heads, through the elbows **(2)** to the exhaust manifolds **(3)**. The coolant circulates completely around the exhaust manifolds forward to the temperature regulator housings **(5)** located at the front of each of the exhaust manifolds.



FLOW OF COOLANT
1–Aftercooler. 2–Elbows. 3–Exhaust manifold. 4–Cylinder heads. 5–Temperature regulator housings. 6–Outlet pipe. 7–Expansion tank. 8–By-pass line. 9–Flywheel housing. 10–Cylinder block. 11–Oil cooler. 12–Water pump. 13–Inlet pipe.

Two regulators, positioned in each housing, control the flow of coolant. With the regulators in the closed position, the coolant passes through a by-pass line **(8)** to the water pump.

When coolant has reached operating temperature, the regulators open. The coolant flows through the outlet pipe **(6)** to the keel cooler **(14)**. The coolant then passes to the expansion tank **(7)** and on to the pump through the inlet pipe **(13)**.

OVERHEATING

If difficulty is experienced with the engine overheating, check the following possible causes:

1. Coolant Level.

   Insufficient coolant in cooling system. If the coolant level has been allowed to fall so low that the coolant is no longer properly circulating, the engine should be stopped immediately and allowed to cool before adding coolant. If there is still good circulation, add make-up coolant slowly while the engine is running. These precautions will minimize the possibility of cracking the cylinder heads.

2. Water Temperature Regulators.

   Failure of water temperature regulators to open. Check the regulators for opening temperature as described in the topic, TESTING TEMPERATURE REGULATORS. Observe the amount of scale deposited on the regulators. Too much scale will obstruct operation. The engine should not be operated with a regulator removed.

3. Water Pump.

   Badly corroded or worn water pump impeller or impeller loose on shaft.

4. Internal Clogging.

   Excessive scale or sediment deposits in keel cooler, cylinder head and block. Such deposits can cause serious damage to the engine by retarding the transfer of heat from the head and cylinders to the coolant. In such cases, the water temperature may not be above normal. However, loose scale and sediment may deposit in water passages to such an extent that circulation will be retarded, in which case the water temperature may go above normal.

   To check for lime and scale in the cooling system, remove one of the precombustion chambers and inspect the surface which comes in contact with the coolant. To remove hard scale, follow the directions in Operation and Maintenance Instructions.

5. Continuous Overload.

   Operating an engine at continuous overload which lugs the engine speed down below its rated speed may also cause overheating. As a correction, reduce the load to allow engine to operate at rated speed.

6. Water Temperature Indicator.

   It may be that the indicator is not registering correctly. If the indicator is suspected of giving a false reading, install a new one and check the reading.

7. Overheating can also be caused by combustion gases escaping by the precombustion chamber gaskets or cylinder head gaskets and water ferrules and seals. The gases can accumulate in the cylinder head and block, thus restricting the flow of coolant through the cooling system.

   Thus, the coolant temperature rises rapidly and hot spots will exist in the cylinder head. The easiest method of checking for this condition is to carefully remove the filler cap and check for air bubbles. If air bubbles are present in the cooling system, check the precombustion chambers for tightness and, if necessary, replace the gaskets.

INTRODUCTION

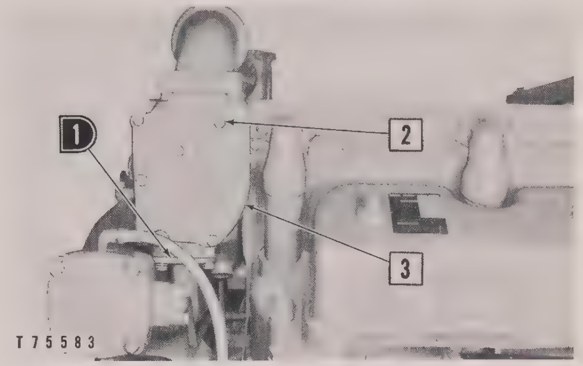
The water temperature regulators are located in housings on the front of the water-cooled exhaust manifolds.

When the engine coolant is cold, the temperature regulators are closed and the flow of coolant to the radiator or heat exchanger is restricted. After the coolant has reached the normal operating temperature, the regulators open and allow the coolant to flow to the radiator or heat exchanger.

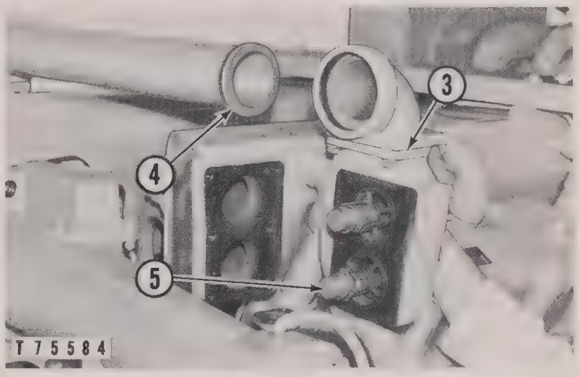
The temperature regulators then control the temperature of the coolant, by regulating the flow of coolant to the radiator or heat exchanger, and maintain a minimum temperature of approximately 165° F. Maximum coolant temperature is dependent upon air (ambient) temperature and engine load but should never be allowed to exceed boiling temperature at the prevailing altitude.

REMOVAL AND INSTALLATION

1. Drain the cooling system until the coolant is below the level of the regulators.
2. Inspect seal **(4)** and replace if necessary.
3. Remove water temperature regulators **(5)** from housing **(3)**.
4. Use similar procedure to remove the water temperature regulators on the right side of the engine.



PREPARING TO REMOVE REGULATOR HOUSING
1–Tube assembly. 2–Bolts (six). 3–Regulator housing.



REMOVING REGULATOR HOUSING
3–Regulator housing. 4–O-ring seal. 5–Regulator.

TESTING TEMPERATURE REGULATORS

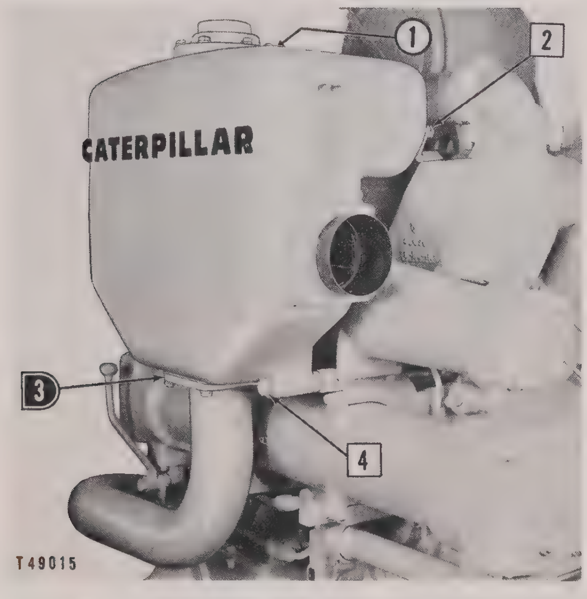
See the SPECIFICATIONS for the correct opening and full open temperatures of the regulator.

Expansion Tank

An expansion tank is used on engines not equipped with a radiator. The expansion tank provides space for the coolant to expand and contains an opening for filling the cooling system. It also holds a reserve supply of coolant thus eliminating the possibility of air locking. A sealed pressure overflow is incorporated in the expansion tanks, on some applications, to maintain a specific pressure within the cooling system.

REMOVAL AND INSTALLATION

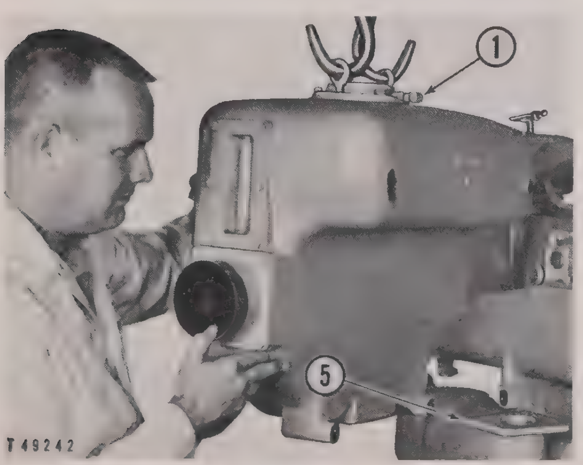
1. Drain the cooling system.
2. Disconnect the sealed pressure overflow line at the fitting **(1)**.
3. Remove the line to the heat exchanger, cooling tower or keel cooler.
4. Install two 3/8" - 16 (NC) eyebolts and support the tank with a suitable hoist as illustrated.
5. Inspect the gasket **(5)**. Install in the reverse order of removal.



PREPARING TO REMOVE EXPANSION TANK

☐ Remove ◗ Disconnect

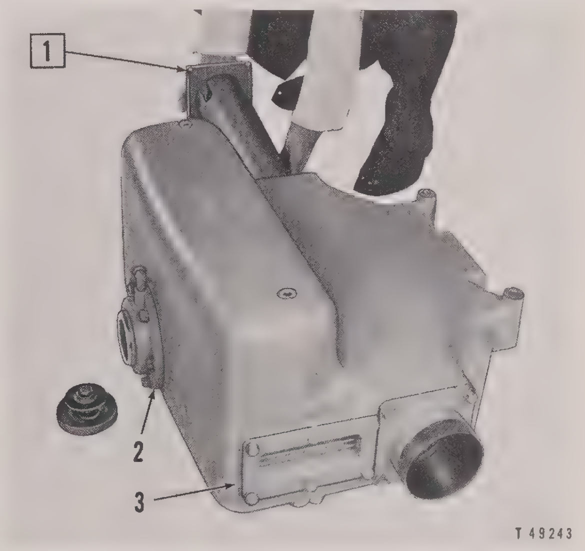
1–Fitting. 2–Bolts (two). 3–Tube assembly. 4–Bolts (two).



REMOVING EXPANSION TANK
1–Fitting. 5–Gasket.

DISASSEMBLY AND ASSEMBLY

The adapter assembly **(2)** and the water level gauge assembly **(3)** can be removed if necessary.



DISASSEMBLING EXPANSION TANK

☐ Remove

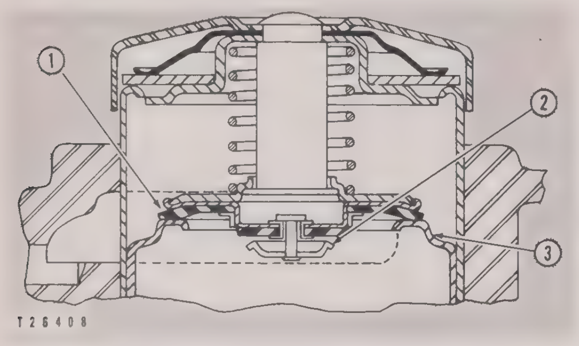
1–Cover assembly. 2–Adapter assembly.
3–Water level gauge assembly.

Inspect the gaskets and assemble in the reverse order of disassembly.

PRESSURE REGULATING CAP

A pressure regulating valve, built into the expansion tank cap, permits a limited amount of pressure within the fresh water cooling system.

Due to expansion of the coolant by rising temperature, pressure will build up in the system each time the engine is started. When this pressure rises above 6 PSI, the seal **(1)** is lifted off the filler neck **(3)** to relieve the pressure or, if the cooling system has been overfilled, to allow some coolant to escape through the overflow tube. The valve closes when the temperature of the coolant levels off and remains closed unless there is a further increase in pressure.



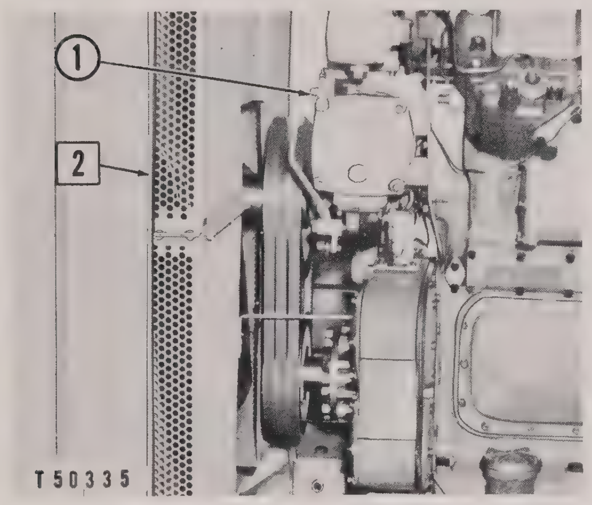
PRESSURE REGULATING CAP
1–Seal. 2–Vacuum relief valve. 3–Filler neck.

When the temperature of the coolant falls, a vacuum will be built up in the cooling system. As soon as the pressure in the system becomes less than atmospheric pressure, the vacuum relief valve **(2)** opens and allows air to enter through the overflow tube. This vacuum relief valve also functions when draining the cooling system.

Fan Group

The fan is driven by three V-belts from a pulley on the crankshaft. The belts and pulleys should be kept clean of any accumulations of dirt and grease to prevent belt slippage which would result in short belt and pulley life and engine overheating.

FAN BELT REPLACEMENT

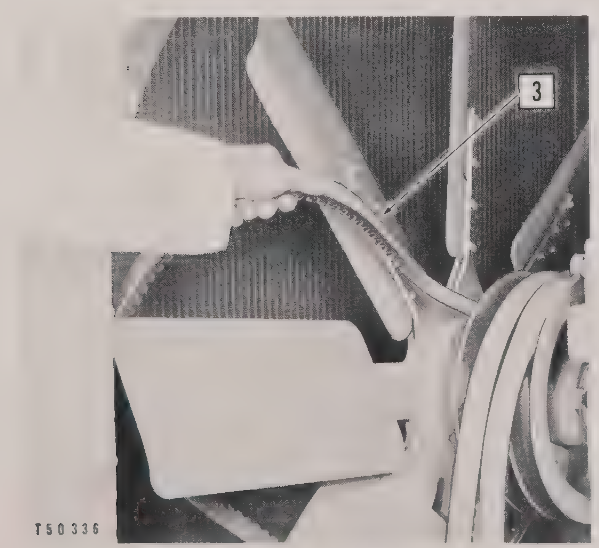


PREPARING TO REMOVE FAN BELTS

☐ **Remove**

1–Bolt (four). 2–Fan guards (four).

1. Loosen the bolts **(1)** which hold the fan mounting bracket to the front accessory drive housing.



REMOVING FAN BELTS

☐ **Remove**

3–Fan belts (three).

2. Loosen the locknut and back off the adjusting screw to allow the fan hub to move to its lowest position.
3. Remove the fan belts **(3)** from the lower pulley and then over the fan blades as shown.

NOTE

It is necessary to rotate the fan when removing the belts.

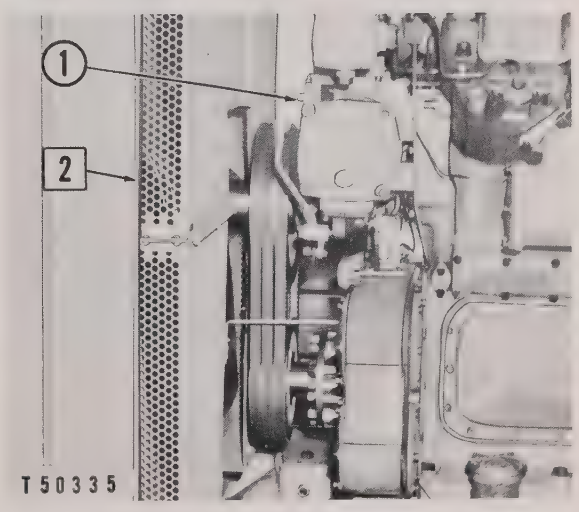
NOTE

Inspect the belts for wear or damage. If any one of the belts needs replacing, install a new set. Always install a matched set of belts, never only one.

4. Adjust the fan belt tension. See the topic, FAN BELT ADJUSTMENT.

FAN AND HUB

Removal and Installation



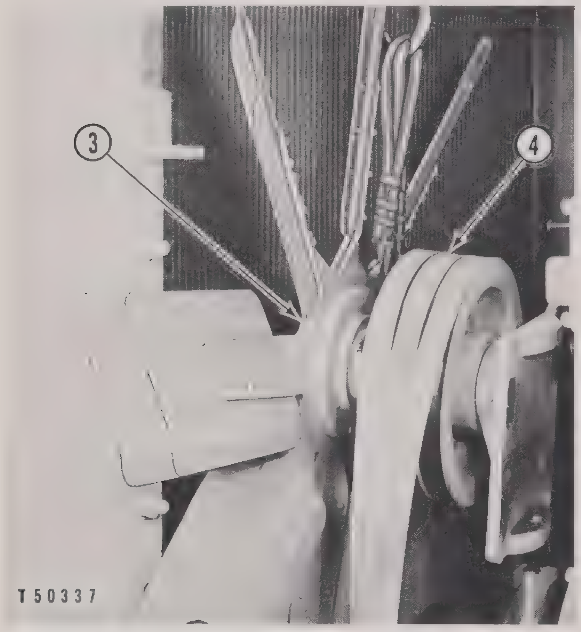
PREPARING TO REMOVE FAN AND HUB

☐ **Remove**

1–Bolt (four). 2–Fan guards (four).

1. Loosen the bolts **(1)** which hold the fan mounting bracket to the front accessory drive housing.
2. Loosen the locknut and back off the adjusting screw to allow the fan hub to move to its lowest position.
3. Remove the fan belts **(4)** from the lower drive pulley.
4. Attach a suitable hoist and sling around the fan hub.

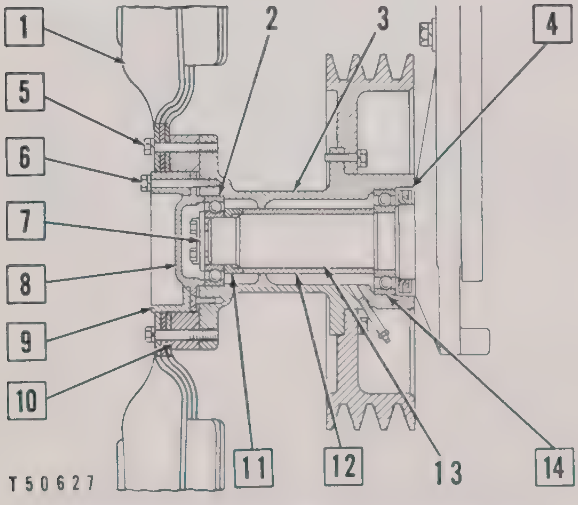
5. Remove the bolts **(1)** holding the fan mounting bracket to the front accessory drive housing and lift out the fan drive group.



REMOVING FAN AND HUB
3–Fan drive group. 4–Fan belts (three).

6. Inspect all parts for wear or damage and replace if necessary.

Disassembly and Assembly



DISASSEMBLING FAN DRIVE (CROSS SECTION)

☐ **Remove**

1–Fan.
2–Bearing.
3–Hub.
4–Seal.
5–Bolt (eight).
6–Bolt (four).
7–Retainer.
8–Cover.
9–Spacer.
10–Spacer.
11–Spacer.
12–Spacer.
13–Shaft.
14–Bearing.

Use a suitable puller to remove the bearing **(2)** and hub **(3)** from the shaft **(13)**.

Inspect all parts for wear or damage and replace if necessary.

NOTE

When installing the seal **(4)**, lubricate the lip of the seal with liquid soap to facilitate installation without damage to the seal. Install the seal with the lip facing away from the bearing.

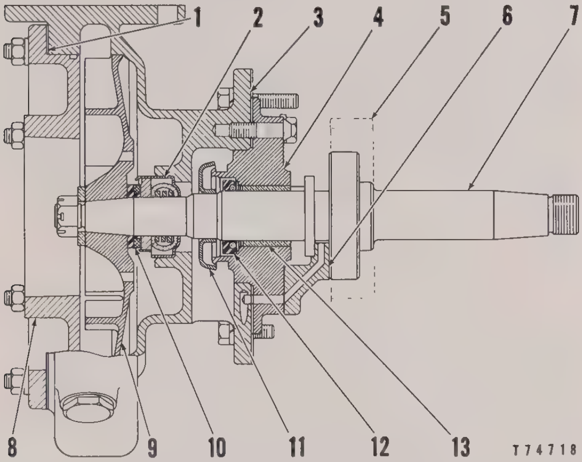
FAN BELT ADJUSTMENT

The fan belts should be checked periodically for proper adjustment. If the fan belts are operated too loose, they will slip on the pulleys causing unnecessary wear to the belts and possibly slipping to the extent that the engine will overheat. If the belts are too tight, unnecessary stresses are placed upon the fan bearings and belts which might shorten the life of both.

Correct adjustment exists when the belts can be pushed inward 9/16″ to ¾″ with approximately 25 pounds force exerted midway between the two pulleys.

INTRODUCTION

The fresh water pump is mounted on the rear side of the upper drive of the accessory drive housing on the right side of the engine. The pump is gear driven and receives lubrication from the engine lubrication system.



WATER PUMP CROSS SECTION
1–Gaskets. 2–Water seal. 3–Pump housing. 4–Bearing retainer. 5–Drive gear. 6–Thrust bearing. 7–Shaft. 8–Inlet cover. 9–Impeller. 10–Seal assembly. 11–Thrower. 12–Oil seal. 13–Bearing.

Correct impeller end clearance is obtained by the amount of gaskets **(1)** between pump housing **(3)** and inlet cover **(8)**. End thrust is taken by thrust bearing **(6)**.

The replaceable carbon washer in water seal **(2)**, held against the face of seal assembly **(10)**, prevents coolant from escaping. In case the seal leaks, a drain opening under pump housing **(3)** allows any coolant leakage to escape. Thrower **(11)** prevents escape coolant from entering the lubricating system through oil seal **(12)**.

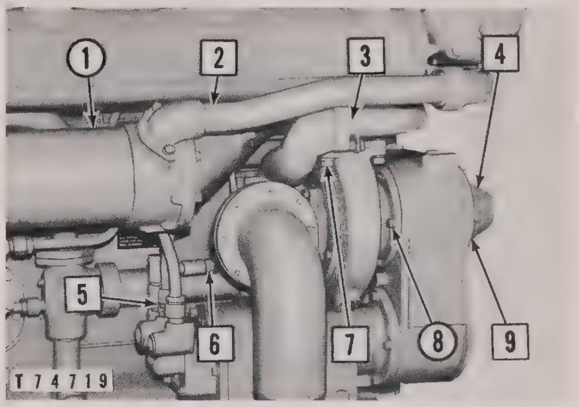
REMOVAL AND INSTALLATION

1. Drain the cooling system including the water pump.
2. Disconnect the cooling system supply line from the water pump inlet elbow.
3. Remove oil cooler **(1)**. See covering topic.

NOTE

Replace the seal and the bearing in bearing retainer **(9)** if damaged. When replacing the bearing, align the bearing oil hole with the groove in bearing retainer **(9)**. Install the seal with the lip facing the bearing.

4. Attach a suitable hoist and remove bolts **(8)** which secure the water pump to the front accessory drive housing. The pump weighs approximately 85 pounds.



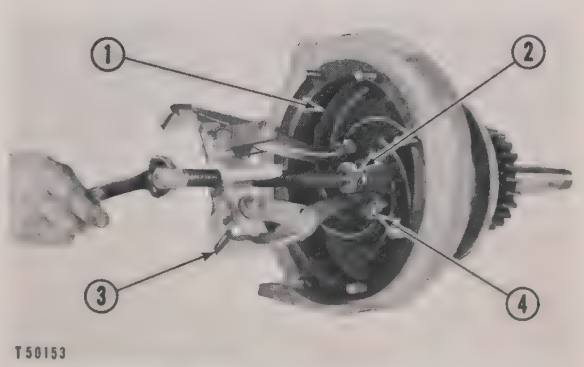
PREPARING TO REMOVE WATER PUMP
1–Oil cooler. 2–Oil tube assembly. 3–Elbow. 4–Cover. 5–Fuel line. 6–Fuel line. 7–Bolts (four). 8–Bolts (six). 9–Bearing retainer (from front of accessory drive housing).

5. Remove the water pump assembly as illustrated.

REMOVING WATER PUMP

DISASSEMBLY AND ASSEMBLY

1. Remove the inlet elbow and cover from the water pump.



REMOVING IMPELLER
1–Impeller. 2–Centering spacer. 3–Puller. 4–Bolts (two).

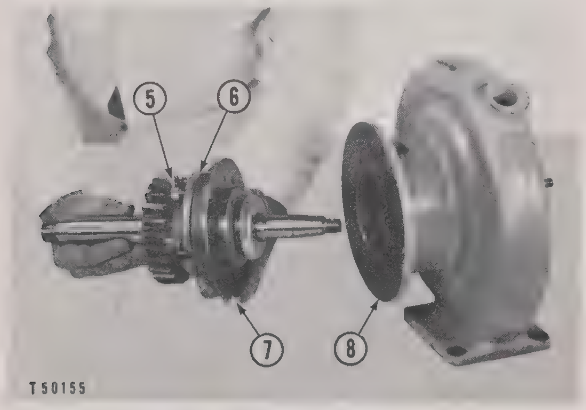
NOTE

Inspect the O-ring seal in the inlet cover and replace if damaged.

2. Insert two 5/16" - 18 NC bolts **(4)** 2" long into the threaded holes in impeller **(1)**.
3. Remove the impeller with 8H700 Puller **(3)** and T774 Centering Spacer **(2)**.

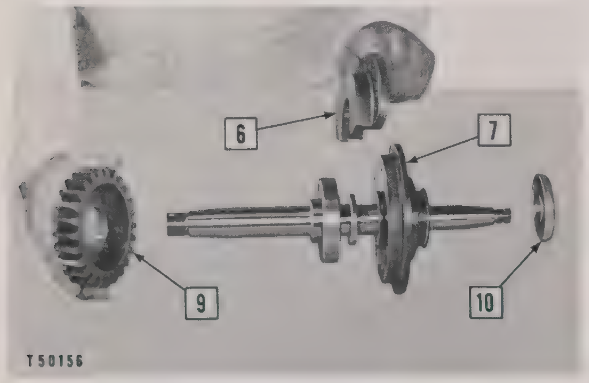
NOTE

Carefully remove the impeller to prevent damage to the seal assembly on later impellers. The seal assembly can adhere to either the impeller or the pump shaft.



REMOVING SHAFT ASSEMBLY
5–Bolts (six). 6–Thrust bearing. 7–Bearing retainer. 8–Pump housing.

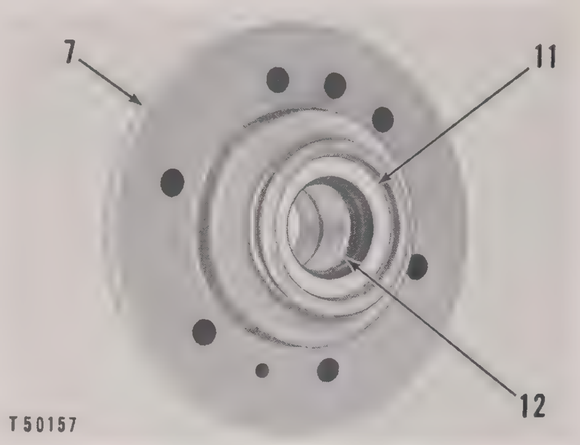
4. Loosen bolts **(5)** which secure thrust bearing **(6)** and bearing retainer **(7)** to pump housing **(8)**. Remove the shaft assembly.



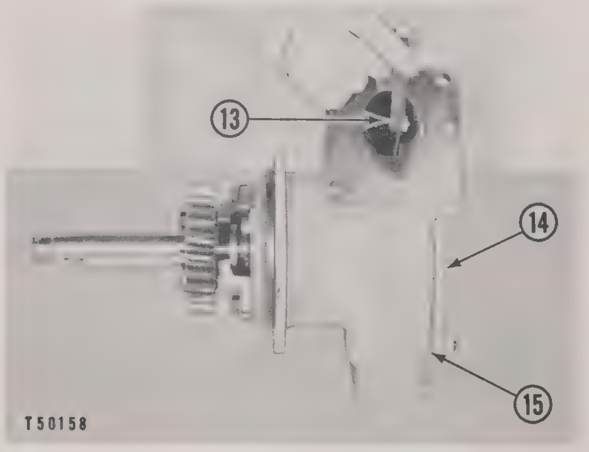
DISASSEMBLING SHAFT ASSEMBLY
6–Thrust bearing. 7–Bearing retainer. 9–Gear. 10–Thrower.

NOTE

Replace oil seal **(11)** and bearing **(12)** if damaged. Install oil seal **(11)** with the lip facing bearing **(12)**.



DISASSEMBLING BEARING RETAINER
7–Bearing retainer. 11–Oil seal. 12–Bearing.



CHECKING IMPELLER END CLEARANCE
13–Thickness gauge. 14–Inlet cover. 15–Gaskets.

5. Check the impeller end clearance by using thickness gauge **(13)** inserted between the impeller and inlet cover **(14)** as shown in the illustration.
6. The amount of gaskets **(15)** regulate impeller end clearance. For the correct impeller end clearance see the SPECIFICATIONS.

WATER PUMP SEAL AND OIL SEAL REPLACEMENT

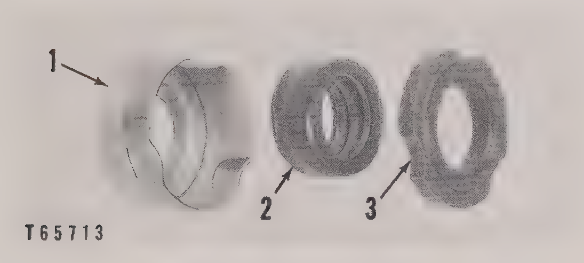
Water draining from the under side of the pump indicates a damaged water seal (either bellows seal assembly or impeller seal assembly or both).

NOTE

It is not necessary to remove the water pump from the engine for water seal replacement.

Remove the impeller as described in the topic, WATER PUMP DISASSEMBLY AND ASSEMBLY.

The seal consists of a carbon thrust washer **(3)** and a spring enclosed by bellows **(2)**. These two parts which make up the replaceable unit are contained in a brass case **(1)**, which is pressed into the water pump housing.



BELLOWS SEAL ASSEMBLY
1–Case. 2–Bellows. 3–Carbon thrust washer.

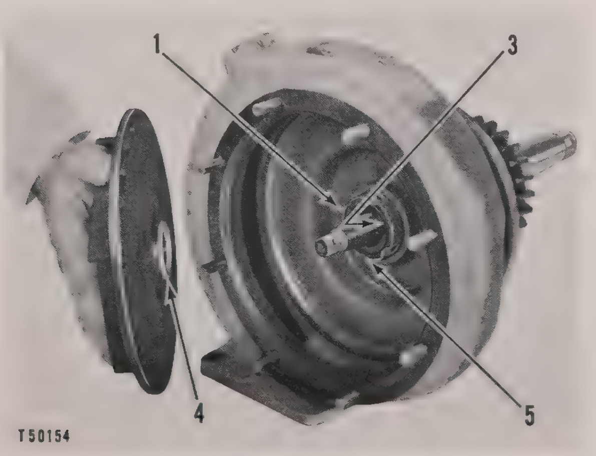
Inspect the contact surfaces of both carbon thrust washer **(3)** and the face of the seal assembly. Both contact surfaces must be smooth and free of nicks or scratches. Replace if damaged.

The impeller seal assembly can be removed after the impeller is removed.

NOTE

Early water pump impellers have a ceramic surface **(4)** bonded to the impeller. The impeller must be replaced if the ceramic surface is damaged.

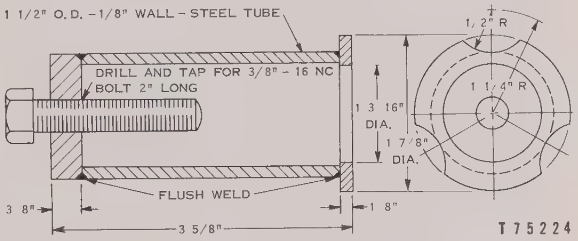
It is not necessary to remove the brass case **(1)** from the water pump housing for seal replacement. The carbon thrust washer **(3)** and the bellows seal **(2)** can be removed from the case by bending back the three ears **(5)** which hold them in place.



WATER SEAL
(Early Pump Impeller)
1–Case. 3–Carbon thrust washer. 4–Ceramic surface. 5–Ears (three).

When replacing the carbon thrust washer, be careful not to crack or scratch it. After the bellows seal and thrust washer are installed, see that the washer moves freely under finger pressure.

If the brass case is damaged, a tool, such as the one shown, can be made for removing it. If a tool is not used, it is necessary to completely disassemble the pump to replace the brass case.


1 1/2" O.D. –1/8" WALL – STEEL TUBE
DRILL AND TAP FOR 3/8" – 16 NC BOLT 2" LONG
FLUSH WELD
3 8"
3 5/8"
1 8"
1 3 16" DIA.
1 7/8" DIA.
1/2" R
1 1/4" R
T75224

WATER SEAL CASE REMOVAL TOOL

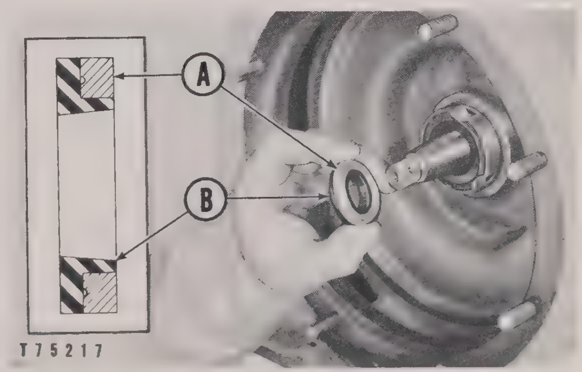
When installing a new brass case, coat the case and housing bore with a lubricant to avoid shearing the brass case, and to provide a positive seal against water leakage.

Make sure the case bottoms squarely in the bore so the carbon washer will bear evenly against the impeller contact surface.

CAUTION

The flange on the case can be bent, if excessive pressure is applied after the case bottoms.

Install the impeller seal assembly with the smooth face of ring **(A)** toward the carbon washer of the bellows seal assembly. The grooved side of the ring faces the rubber seal **(B)**.



IMPELLER SEAL ASSEMBLY
(Later Water Pumps)
A–Rings. B–Rubber seal.

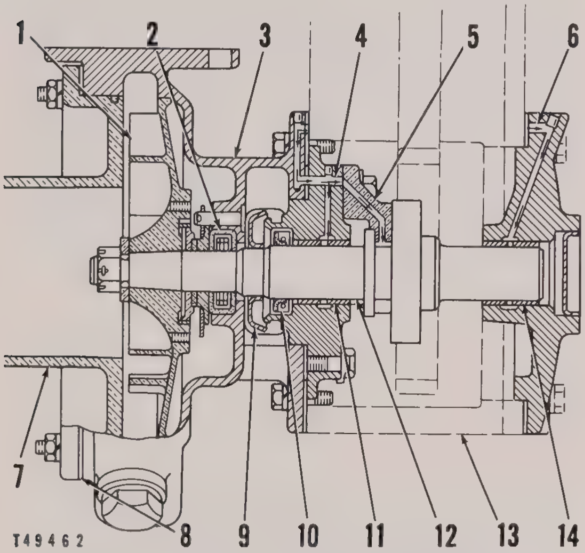
If it becomes necessary to replace the oil seal, the pump must be disassembled.

Press the old seal out and install a new one, with the lip of the seal toward the bearing.

Raw Water Pump

The raw water pump is mounted on the lower left front corner of the front accessory drive housing **(13)**. The pump shaft **(12)** and bearings **(11)** and **(14)** receive their lubricant by way of passages **(4)** and **(6)**. End thrust is taken by the thrust bearing **(5)** which also receives its lubricant through passage **(4)**. An oil seal **(10)** prevents the loss of lubricant from the lubricating system.

The water seal **(2)** and water thrower **(9)** prevent any water from entering the lubricating system. A hole in the bottom of the pump housing **(3)** allows for the escape of any water which by-passes the water seal.



CROSS SECTION OF RAW WATER PUMP

1–Impeller.
2–Water seal.
3–Pump housing.
4–Oil passage.
5–Thrust bearing.
6–Oil passage.
7–Inlet elbow.
8–Gaskets.
9–Water thrower.
10–Oil seal.
11–Bearing.
12–Shaft.
13–Front accessory drive housing.
14–Bearing.

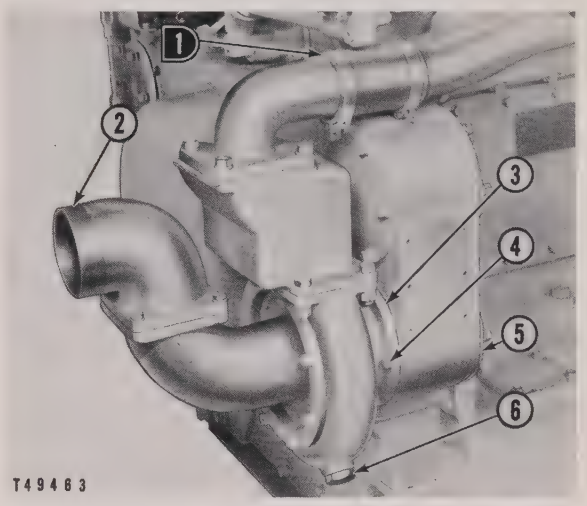
Gaskets **(8)** between the inlet elbow **(7)** and pump housing **(3)** are used to adjust the impeller end clearance.

REMOVAL AND INSTALLATION

1. Drain the raw water system by removing the plug **(6)**.
2. Disconnect the raw water inlet line from the elbow **(2)**.

NOTE

The bearing retainer **(5)** should be removed to inspect the pump shaft bearing which is pressed into the retainer. Replace the bearing if necessary.

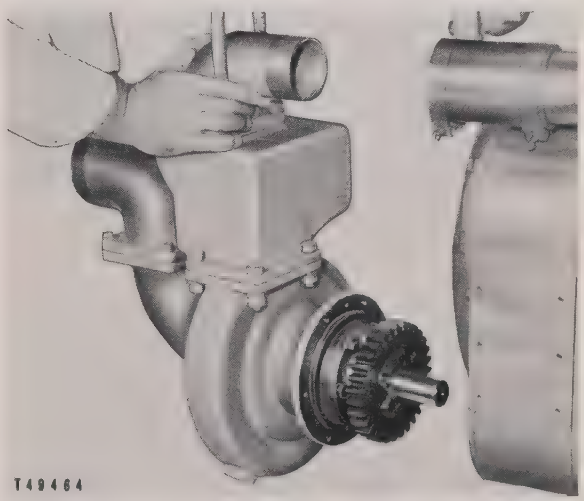


PREPARING TO REMOVE RAW WATER PUMP

D Disconnect

1–Hose. 2–Elbow. 3–Raw water pump. 4–Bolts (six). 5–Bearing retainer. 6–Plug.

3. Attach a suitable hoist and remove the bolts **(4)** which secure the raw water pump **(3)** to the front accessory drive housing.
4. Remove the raw water pump assembly as shown.

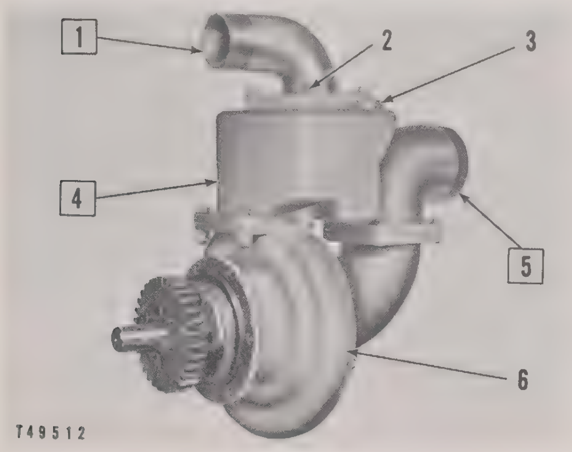


REMOVING RAW WATER PUMP ASSEMBLY

DISASSEMBLY AND ASSEMBLY

NOTE

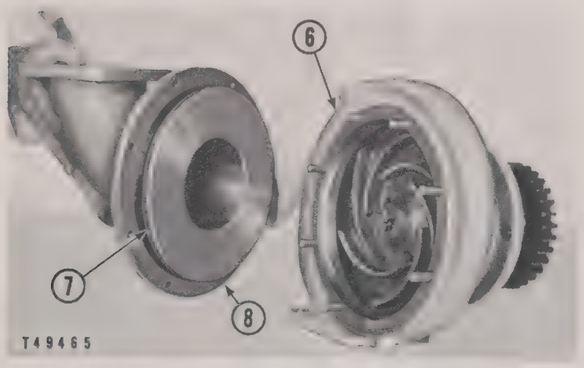
Outlet elbow **(1)** and primer tank **(4)** can be removed as a unit but it is necessary to first remove the bolt **(2)** which extends through the primer tank into the pump housing **(6)**. The primer plug **(3)** can be removed to fill the primer tank after the unit is assembled and installed.



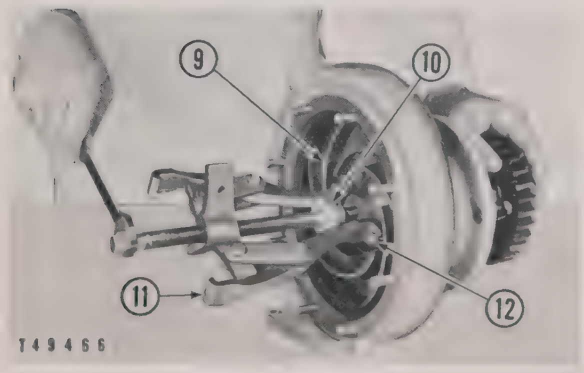
PREPARING TO DISASSEMBLE RAW WATER PUMP

☐ **Remove**

1–Outlet elbow. 2–Bolt. 3–Primer plug. 4–Primer tank. 5–Inlet elbow. 6–Pump housing.



REMOVING INLET ELBOW
6–Pump housing. 7–O-ring seal. 8–Inlet elbow and cover.

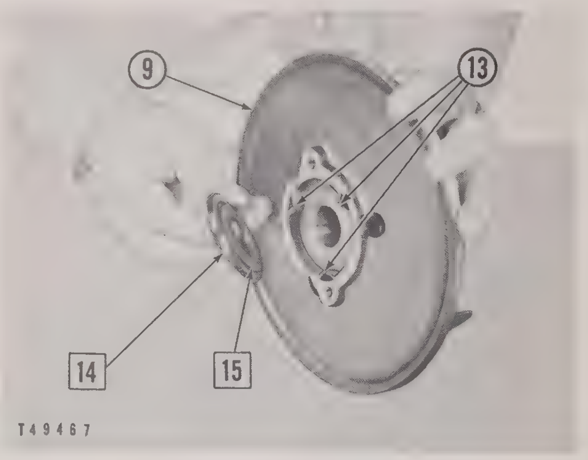


REMOVING IMPELLER
9–Impeller. 10–Centering spacer. 11–Puller. 12–Bolt.

1. Remove the inlet elbow and cover **(8)** from pump housing **(6)** and inspect the O-ring seal **(7)**.

2. Insert two 5/16″ - 18 (NC) bolts **(12)** 2″ long into the holes provided in the impeller **(9)**.

3. Remove the impeller with the aid of an 8H700 Puller **(11)** and T774 Centering Spacer **(10)**.



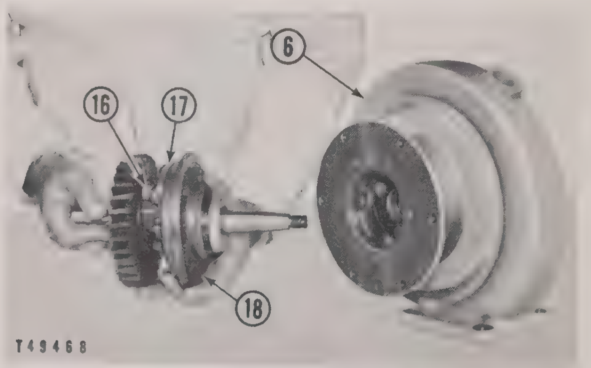
DISASSEMBLING IMPELLER

☐ **Remove**

9–Impeller. 13–Locks. 14–Plate assembly. 15–Gasket.

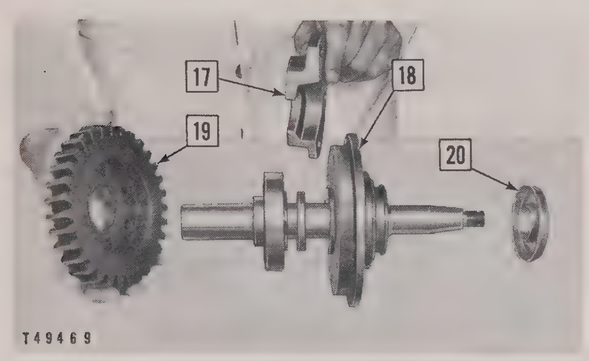
NOTE

When installing the plate assembly **(14)** and gasket **(15)** in the impeller **(9)**, bend the locks **(13)** to hold them securely in place.



REMOVING SHAFT ASSEMBLY
6–Pump housing. 16–Bolt. 17–Thrust bearing. 18–Bearing retainer.

4. Remove the bolts **(16)** securing the thrust bearing **(17)** and bearing retainer **(18)** to the pump housing **(6)**. Remove the shaft assembly as shown.



DISASSEMBLING SHAFT ASSEMBLY

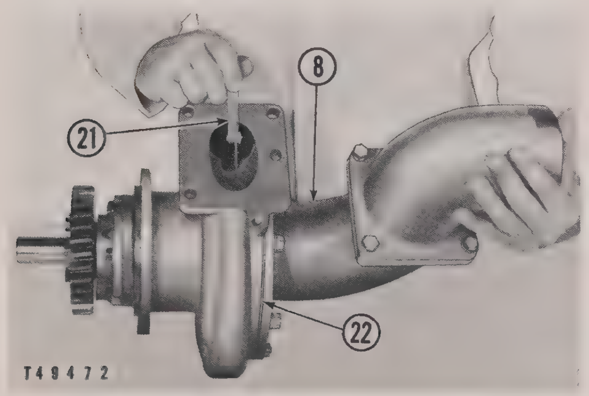
☐ Remove

17–Thrust bearing. 18–Bearing retainer. 19–Gear. 20–Water thrower.

NOTE

The bearing and oil seal can be removed from the bearing retainer **(18)** if replacement is deemed necessary. The oil seal should be installed with the lip facing the gear **(19)**.

5. Upon assembly check the impeller end clearance using a thickness gauge **(21)** inserted between the impeller and inlet elbow **(8)** as illustrated.
6. Use the necessary amount of gaskets **(22)** to obtain the correct end clearance. See the topic, SPECIFICATIONS.

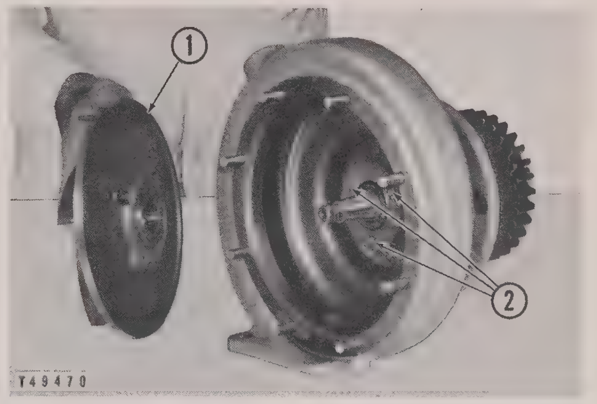


CHECKING IMPELLER END CLEARANCE
8–Inlet elbow and cover. 21–Thickness gauge. 22–Gaskets.

WATER SEAL REPLACEMENT

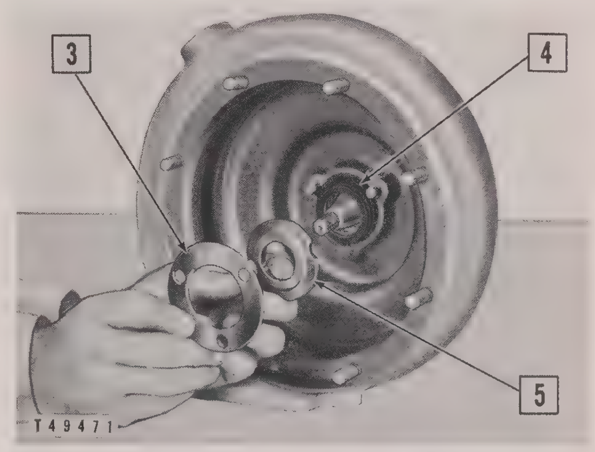
Water leaking from the drain hole in the bottom of the pump indicates that the water seal should be replaced. The seal may be replaced with the pump either installed or removed from the engine.

1. Remove the water pump inlet elbow and impeller **(1)** as previously described.



PREPARING TO REMOVE WATER SEAL
1–Impeller. 2–Dowel pins.

2. Remove the retaining pins from the dowel pins **(2)**.



REMOVING WATER SEAL

☐ Remove

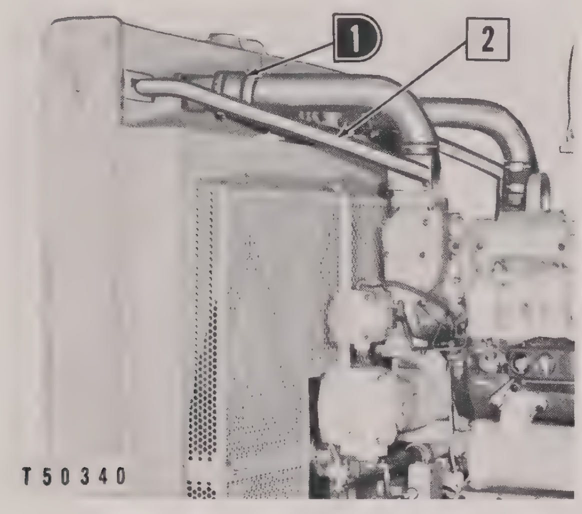
3–Retainer ring. 4–Bellows assembly. 5–Plate.

3. Inspect and replace any worn or damaged parts.
4. Use new retaining pins upon assembly.
5. Check the impeller end clearance. See the previous topic.

Radiator

REMOVAL AND INSTALLATION

1. Drain the coolant from the radiator.

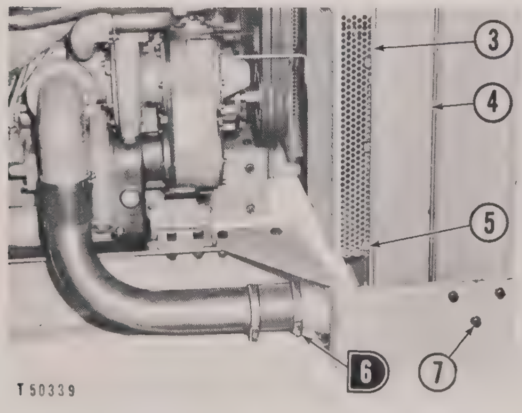


PREPARING TO REMOVE RADIATOR

☐ Remove ◗ Disconnect

1–Radiator inlet line (two). 2–Brace (two).

2. Remove the bolts **(5)** that secure the fan guard **(3)** to the fan shroud **(4)**.

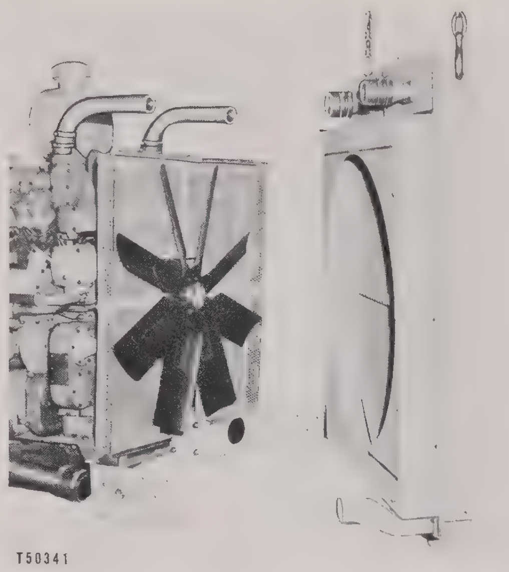


PREPARING TO REMOVE RADIATOR

◗ Disconnect

3–Fan guard. 4–Fan shroud. 5–Bolts (twenty-four). 6–Radiator outlet line. 7–Bolts (six).

3. Attach a suitable hoist and remove the bolts **(7)** that secure the radiator to the lower support bracket.
4. Lift the radiator slightly and swing it free of the fan.
5. Inspect all parts for wear or damage and replace if necessary.



REMOVING RADIATOR

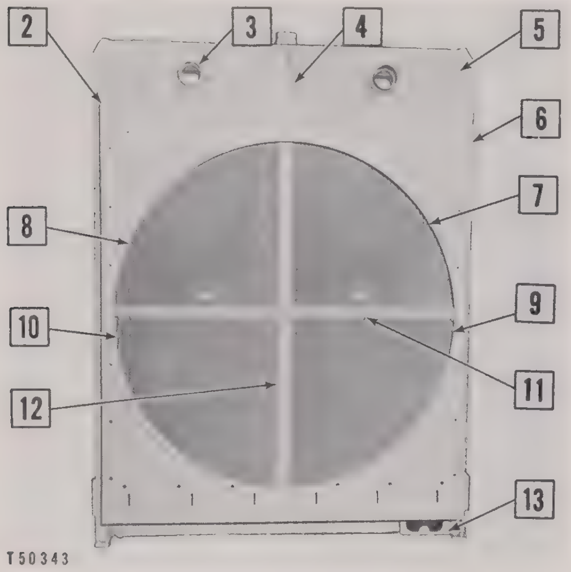
DISASSEMBLY AND ASSEMBLY

PREPARING TO DISASSEMBLE RADIATOR

☐ Remove

1–Guard.

1. Remove the radiator outlet elbow from the bottom tank **(13)**.
2. Clean the radiator water cores of all accumulations of debris between the fins and tubes with water or compressed air. Such accumulations decrease the efficiency of the cooling system and may cause the engine to overheat.



DISASSEMBLING RADIATOR

☐ Remove

2–Shroud. 3–Clamp, hose, and pipe (two). 4–Overflow tube. 5–Top tank. 6–Side assembly (two). 7, 8, 9, and 10–Cores. 11–Tank. 12–Post assembly. 13–Bottom tank.

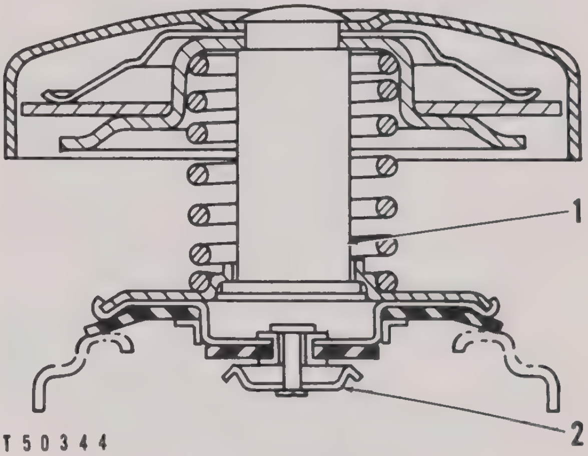
3. The inside of the radiator cores, bottom tank, and top tank should be cleaned with commercial radiator cleaner according to the instructions furnished by the manufacturer.
4. Test the radiator for possible leaks before installing the radiator on the engine. This can be accomplished by plugging both the inlet and outlet openings and filling the radiator with water. Leave the water in the radiator for a long enough period of time to detect any seepage that might occur.

PRESSURE VALVE CAP

A sealed pressure overflow assemby built in the radiator cap prevents loss of coolant through the radiator overflow tube when the engine is operating on an incline.

Due to expansion of the coolant by rising temperature, pressure will be built up in the cooling system each time the engine is started. When the pressure rises above 6 PSI, the pressure relief valve **(1)** opens to relieve the pressure, or, if the cooling system has been overfilled, allow some coolant to escape through the radiator overflow tube. The valve closes when the temperature of the coolant levels off and remains closed unless there is a further increase in pressure.

When the temperature of the coolant falls, a vacuum will result in the cooling system. The vacuum release valve **(2)** opens when the vacuum reaches 1 PSI and lets in air through the overflow tube. This vacuum release valve also functions when draining the cooling system, however it is better to remove the cap to permit faster flow.



PRESSURE VALVE CAP
1–Pressure relief valve. 2–Vacuum release valve.

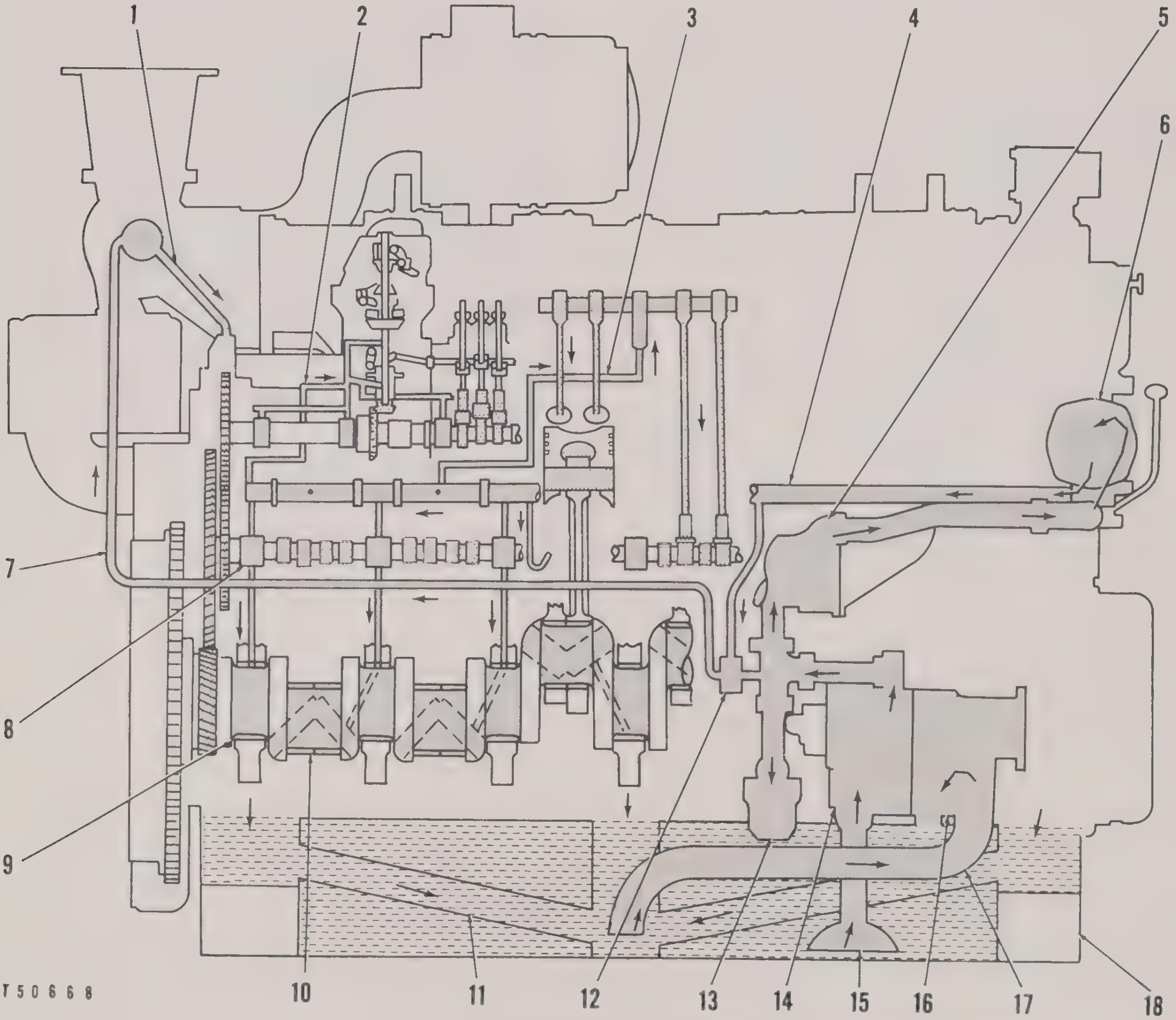
Lubricating System

On a marine engine or other engine which may be required to operate on an inclined position, a two-section oil pump is used. One section picks up oil from the scavenge sumps and delivers it to the main sump. The other section of the pump picks up oil from the main sump and delivers it under pressure to the engine.

If the engine is to be operated in a stationary or horizontal position, it will be equipped with a single-section pump and an oil pan without scavenge sumps. Since the two pumps are similar in design and operation, only the more complicated two-section pump will be discussed here.

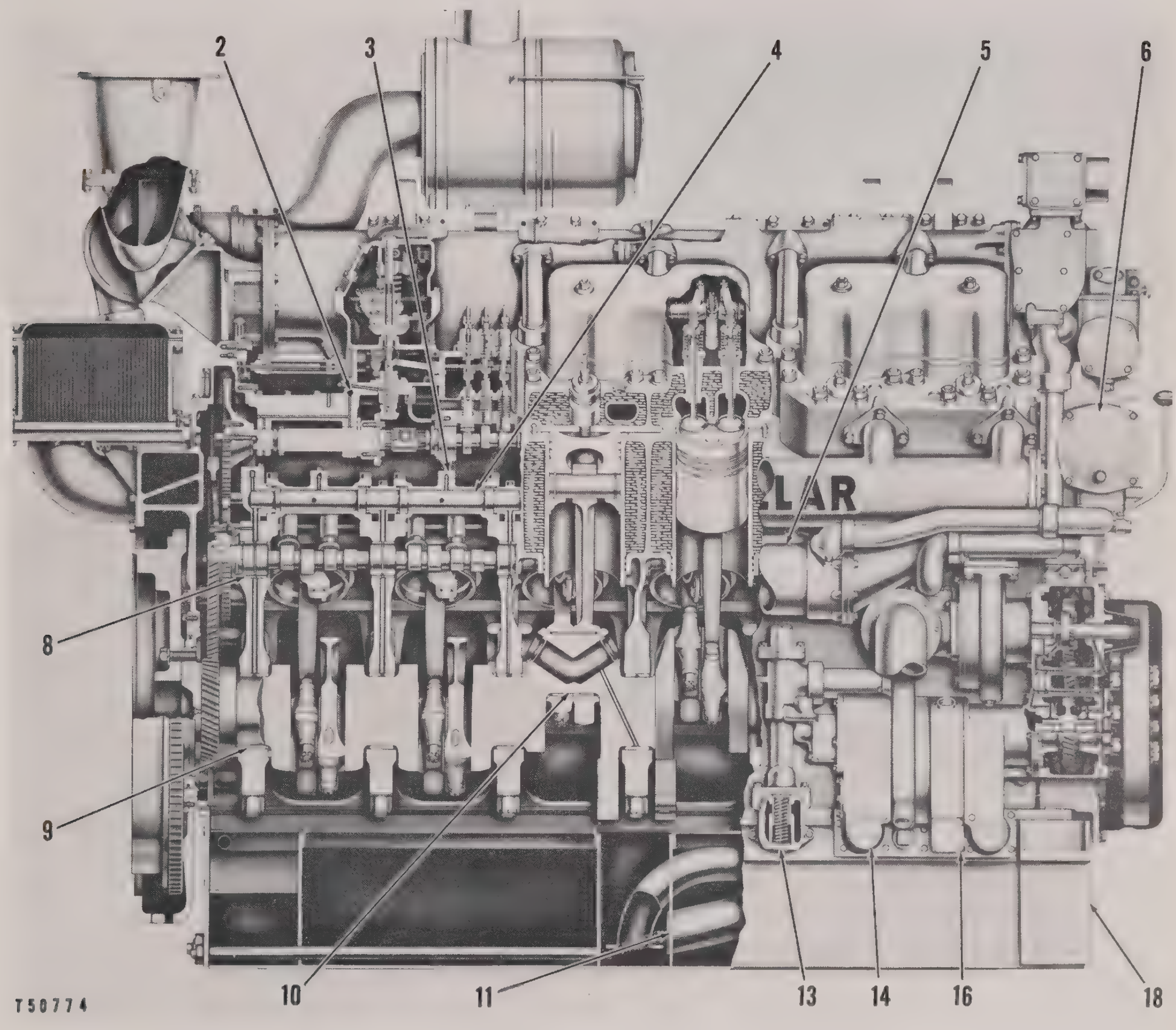
Over

FLOW OF LUBRICATING OIL



FLOW OF LUBRICATING OIL (SCHEMATIC)

1–Turbocharger oil return line.
2–Governor oil supply line.
3–Valve mechanism supply line.
4–Oil distribution manifold.
5–Oil cooler.
6–Oil filter.
7–Turbocharger oil supply line.
8–Camshaft bearing.
9–Crankshaft main bearing.
10–Crankshaft connecting rod bearing.
11–Scavenge sump tube.
12–Turbocharger lubrication valve.
13–Pressure regulating valve.
14–Oil pump.
15–Suction bell.
16–Scavenge pump.
17–Scavenge pump supply line.
18–Oil pan.



FLOW OF LUBRICATING OIL

2–Governor oil supply line.
3–Valve mechanism supply line.
4–Oil distribution manifold.
5–Oil cooler.
6–Oil filter.
8–Camshaft bearing.
9–Crankshaft main bearing.
10–Crankshaft connecting rod bearing.
11–Scavenge sump tube.
13–Pressure regulating valve.
14–Oil pump.
16–Scavenge pump.
18–Oil pan.

A two-section oil pump **(14)** is driven from the front accessory drive and supplies oil to the engine for cooling and lubricating purposes.

NOTE

The scavenge pump **(16)**, the scavenge pump supply line **(17)**, and this type of oil pan are used only on engines which have a possibility of tilt operation, such as marine engines.

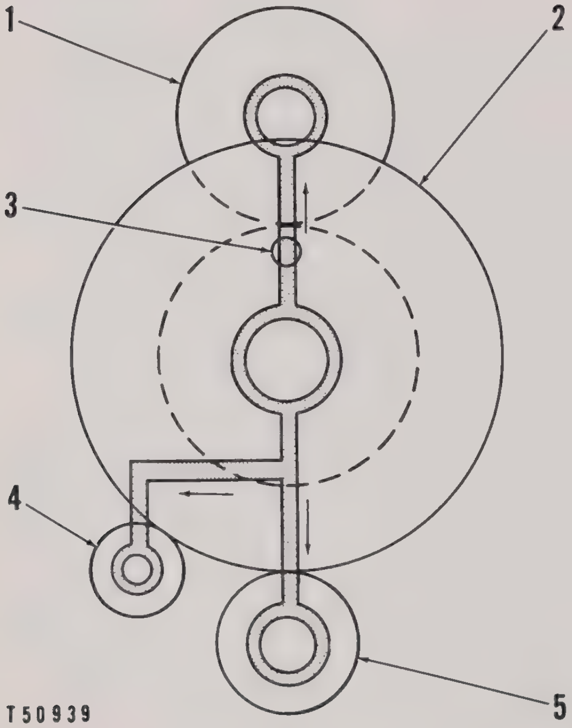
A pressure-operated turbocharger lubrication valve **(12)** has two inlet sources. One source is directly from the oil pump which allows delivery of oil to the turbochargers almost immediately upon starting of the engine. When the oil in the system reaches normal operating pressure, the valve switches and directs filtered oil to the turbochargers.

The pressure regulating valve **(13)** dumps excess oil back into the oil pan **(18)**.

Oil is supplied to the crankshaft bearings **(9)** and **(10)**, camshaft bearings **(8)**, valve mechanism, fuel injection pumps, governor and pistons by means of the distribution manifold **(4)**.

TIMING GEARS

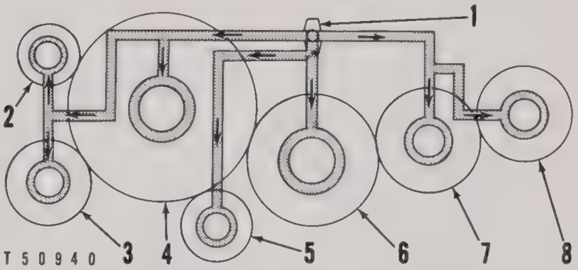
Oil under pressure flows from the oil distribution manifold junction **(3)** to the bearings that support the camshaft gear **(2)**, the governor drive gear **(1)**, the crankshaft **(5)** and the balancer gear **(4)**, which is used on the D379 only.



TIMING GEAR LUBRICATION
1–Governor drive gear. 2–Camshaft gear. 3–Oil distribution manifold junction. 4–Balancer gear. 5–Crankshaft.

FRONT ACCESSORY DRIVE

The front accessory drive lubricating oil flows from the oil distribution manifold junction **(1)**. Steel tubes in the front accessory drive housing supply oil to the bearings which support the crankshaft **(6)**, idler gears **(7)** and **(8)**, water pump gear **(2)**, oil pump gear **(3)** and main idler gear **(4)**. The bearing which supports the balancer gear **(5)**, used on the D379 only, receives oil through a drilled passageway in the block.



FRONT ACCESSORY DRIVE LUBRICATION
1–Oil distribution manifold junction. 2–Water pump gear. 3–Oil pump gear. 4–Main idler gear. 5–Balancer gear. 6–Crankshaft. 7–Idler gear. 8–Idler gear.

OIL PRESSURE

When the engine is warm and running at rated speed, the gauge should register in the operating range. A lower pressure reading is normal at low idling speeds.

If for any reason the oil gauge registers no pressure, the engine should be stopped immediately until the difficulty can be determined and corrected.

A small orifice in the gauge connection prevents rapid gauge fluctuation. This orifice should be checked for dirt, in the event the gauge becomes inoperative.

If the oil pressure gauge indicates low or no oil pressure, check for the following:

1. Low oil level.
2. Clogged oil filters.
3. Defective oil gauge, or a clogged or broken tube to the gauge.
4. Clogged oil pump screen.
5. Leaking connections.
6. Loose bearings.
7. Pressure regulating valve worn or stuck, thus restricting the flow of oil.
8. Worn oil pump gears.

Oil Pan

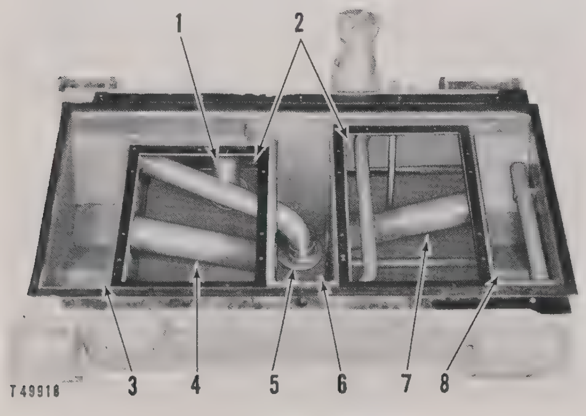
The engine oil pump picks up oil from the main oil sumps **(2)** through a suction bell **(1)**. The main oil sumps are connected by passages beneath the center scavenge pump **(6)**.

Two end scavenge sumps **(3)** and **(8)** are connected to the center scavenge sump by tubes **(4)** and **(7)**. The scavenge pump picks up oil from the center sump **(6)** through a suction bell **(5)** and delivers the oil to the main sumps through a passage in the oil pan base.

Two plates are installed over the main oil sumps and are sealed with a rubber gasket.

NOTE

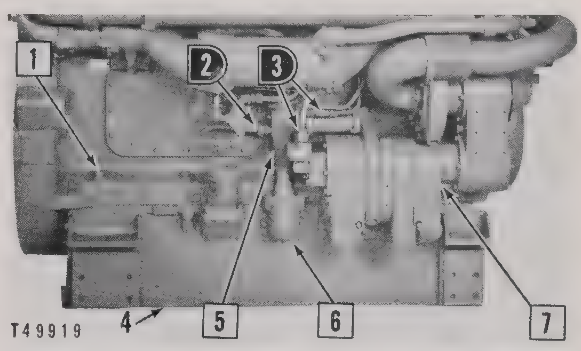
Engines equipped with a single-section oil pump do not have the scavenge sumps. The entire pan forms a single reservoir rather than the divided system shown here. See the topic, DISASSEMBLY AND ASSEMBLY (ENGINES EQUIPPED WITH SINGLE-SECTION PUMP), for illustration.



OIL PAN BASE ASSEMBLY
1–Main oil pump suction bell. 2–Main sumps. 3–Front scavenge sump. 4–Tube. 5–Scavenge pump suction bell. 6–Center scavenge sump. 7–Tube. 8–Rear scavenge sump.

REMOVAL AND INSTALLATION

1. Attach a suitable hoist to the engine and lift it from the base.
2. Remove the base from under the engine and block the engine securely.
3. Inspect the gaskets and replace if damaged.
4. Install in the reverse order of removal.

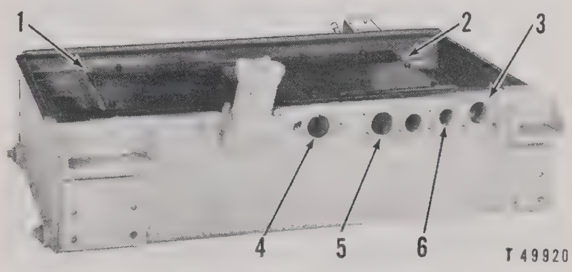


PREPARING TO REMOVE THE OIL PAN BASE

☐ **Remove** ● **Disconnect**

1–Bolts. 2–Turbocharger lubrication valve inlet line. 3–Fuel transfer pump fuel lines. 4–Oil pan base. 5–Tee assembly. 6–Regulating valve. 7–Oil pump assembly.

DISASSEMBLY AND ASSEMBLY
(Engines Equipped with Two-section Pump)



OIL PAN BASE ASSEMBLY
1–Plate. 2–Plate. 3–Scavenge pump outlet. 4–Regulating valve inlet. 5–Main pump suction outlet. 6–Scavenge pump return inlet.

Remove the plates **(1)** and **(2)** to inspect the oil pan base.

NOTE

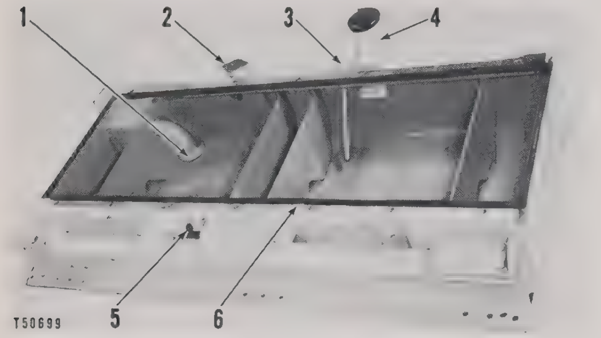
A screen assembly behind the scavenge pump outlet can be serviced by removing the cover on the front of the oil pan base. Make certain no air or oil leaks exist when reassembled.

There is a screen between the oil pan base and filler pipe. Inspect the screen and clean or replace if necessary.

Replace the gaskets if damaged.

DISASSEMBLY AND ASSEMBLY
(Engines Equipped with Single-section Pump)

1. A screen in front of the suction bell **(1)** can be removed for service or replacement by removing the cover on the front of the oil pan base assembly. Make certain no air or oil leaks exist when reassembled.



OIL PAN BASE ASSEMBLY
1–Suction bell. 2–Reguating valve. 3–Oil level gauge. 4–Oil filler pipe. 5–Oil level gauge. 6–Gasket.

NOTE

For removal of the regulating valve **(2)**, see the covering topic.

2. There is a screen between the oil pan base and the filler pipe **(4)**. Inspect the screen and clean or replace if necessary.
3. Inspect the gaskets **(6)** and replace if necessary. The gasket is made in sections and if any section is damaged, all the sections should be replaced.
4. Assemble in the reverse order of disassembly.

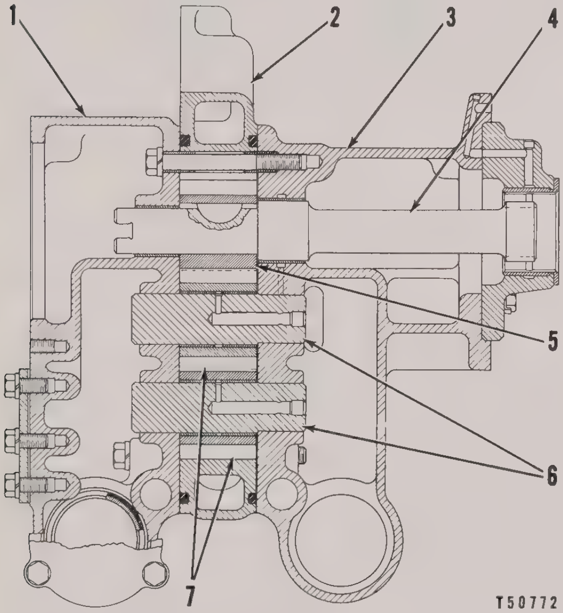
Oil Pump

(Single Section Pump)

OPERATION AND LUBRICATION

The oil pump is a single section, outlet pressure controlled, gear type pump, driven by an idler gear from the front gear of the crankshaft.

The pump is bolted to the lower right front corner of the engine block.



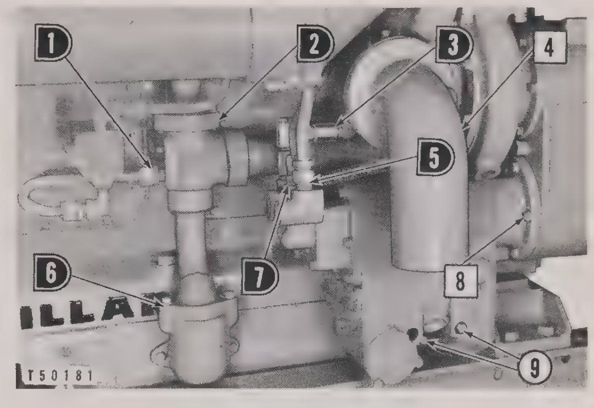
OIL PUMP
1–Rear manifold. 2–Pressure oil manifold. 3–Oil intake manifold. 4–Drive shaft. 5–Drive gear. 6–Idler shafts. 7–Idler gears.

The pump draws oil from the sump in the engine base and delivers it to the engine block for engine lubrication. The pressure regulating valve limits the oil pressure to the main bearings to approximately 45 PSI.

OIL PUMP REMOVAL AND INSTALLATION

When all lines have been disconnected and the bolts **(8)** removed, support the pump assembly with a suitable hoist and then remove the bolts **(9)**.

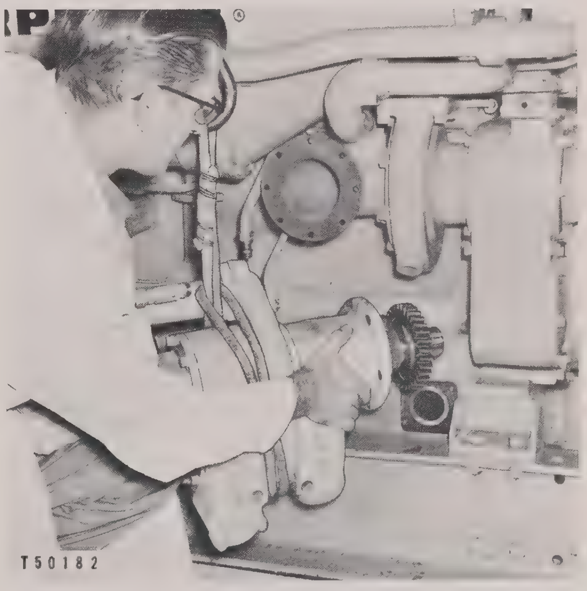
Install in reverse order of removal.



PREPARING TO REMOVE THE OIL PUMP

☐ Remove ● Disconnect

1–Oil tube. 2–Pressure oil pipe connection. 3–Fuel supply line. 4–Water inlet elbow. 5–Fuel return line. 6–Pressure oil pipe connection. 7–Fuel priming pump line. 8–Bolts (six). 9–Bolts (two).

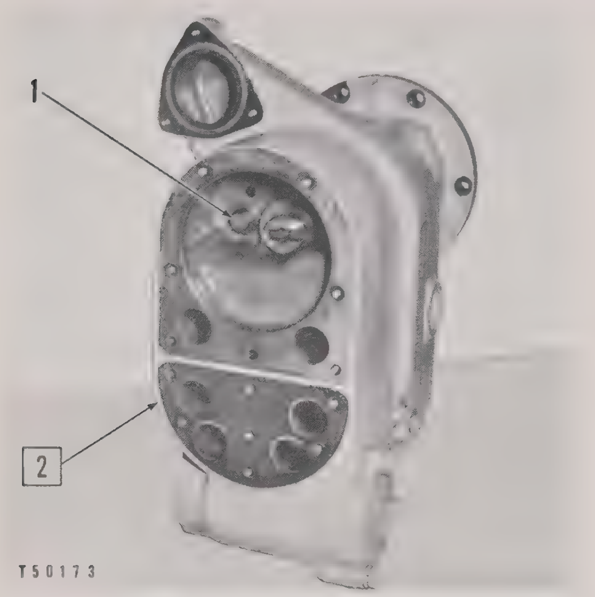


REMOVING OIL PUMP

OIL PUMP DISASSEMBLY AND ASSEMBLY

1. Remove the fuel transfer pump as described in the topic, FUEL TRANSFER PUMP.
2. Remove the outlet tube assembly from the pressure oil manifold **(4)** and the cover plate from the bottom of the oil pump.
3. Remove the nine bolts **(1)** which secure the rear manifold **(2)** to the pump assembly.

Over



REAR MANIFOLD REMOVAL

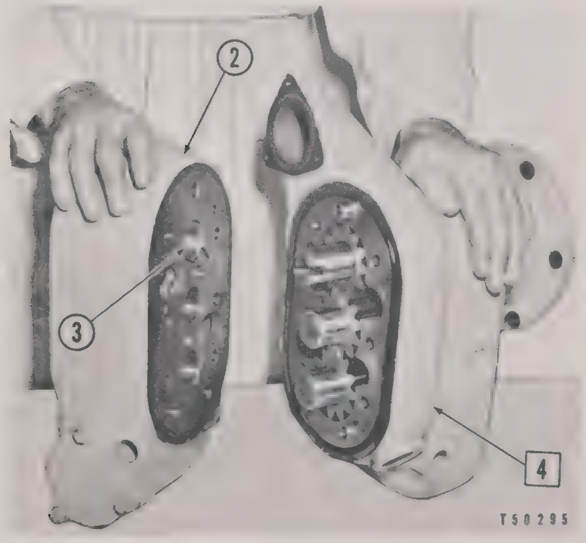
☐ Remove

1–Bolt. 2–Rear manifold.

4. Inspect the bearing **(3)** and replace if necessary by driving the bearing out of the rear manifold **(2)**.

NOTE

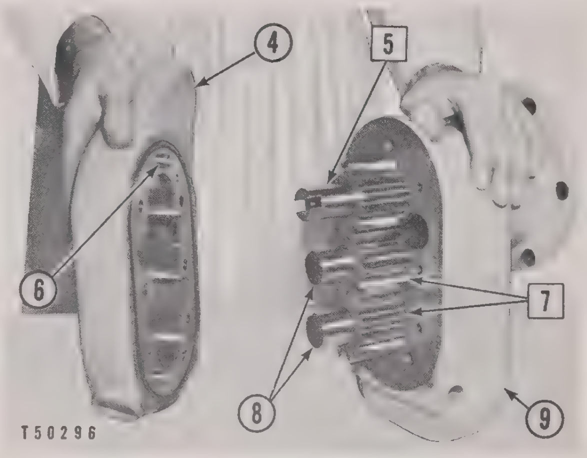
During assembly, the two longest bolts **(1)** go into the lower two holes in the manifold **(2)**.



PREPARING TO DISASSEMBLE OIL PUMP

☐ Remove

2–Rear manifold. 3–Drive shaft bearing. 4–Pressure oil manifold.



OIL PUMP DISASSEMBLY

☐ Remove

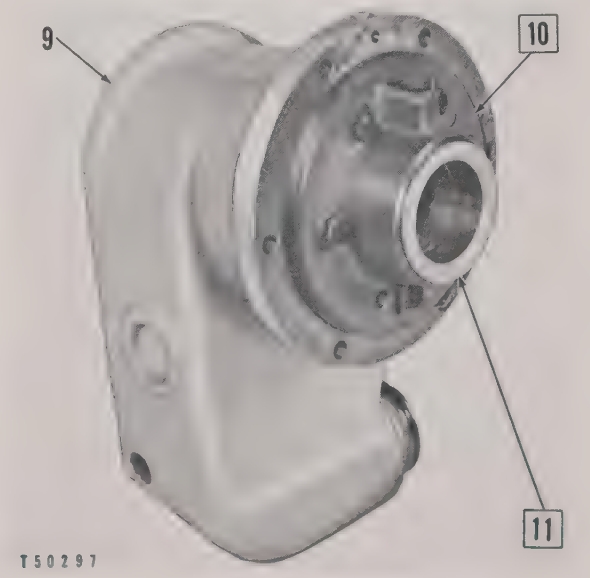
4–Pressure oil manifold. 5–Drive shaft. 6–Dowel. 7–Idler gears. 8–Idler shafts. 9–Oil intake manifold.

5. The drive gear which is keyed and pressed onto the drive shaft **(5)** can be removed if necessary.

6. The idler shafts **(8)** are pressed into the oil intake manifold **(9)**. Inspect the shafts and manifold for wear and replace if necessary.

CAUTION

When assembling the pump, be sure the dowels **(6)** on both sides of the pressure oil manifold **(4)** are aligned correctly.



BEARING REMOVAL

☐ Remove

9–Oil intake manifold. 10–Retainer. 11–Bearing.

7. Inspect the bearings at both ends of the oil manifold **(9)**.

NOTE

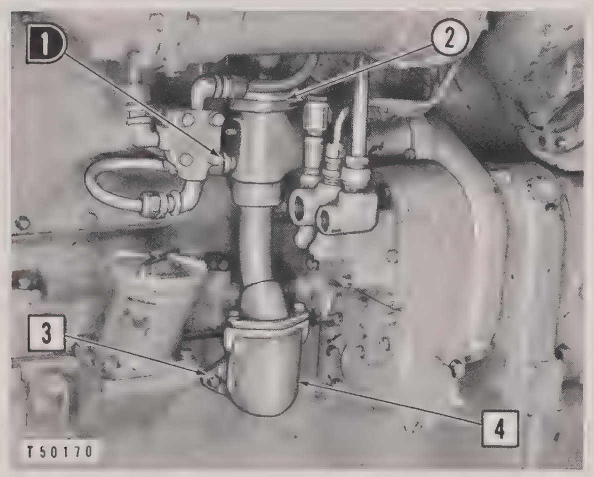
If either bearing **(11)** or the bearing at the other end of the oil manifold **(9)** requires replacement, remove the retainer **(10)** and press out the bearing.

8. Check all O-ring seals for damage and assemble the pump in reverse order of disassembly.

PRESSURE REGULATING VALVE

The pressure regulating valve is located directly to the rear of the oil pump. The valve maintains an oil pressure limit of approximately 45 PSI at the gauge. Excess oil which passes the pressure regulating valve dumps directly into the oil pan.

Removal and Installation



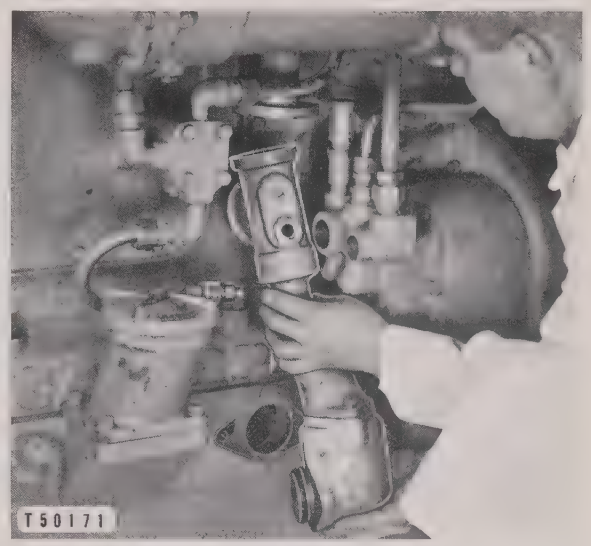
PREPARING TO REMOVE THE REGULATING VALVE

☐ **Remove** ◗ **Disconnect**

1–Oil tube. 2–Flange. 3–Bolt (two). 4–Regulating valve housing and tube assembly.

Remove the bolts which secure the pipe to the flange **(2)**.

Work the regulator valve housing out of the block and the tube assembly away from the oil pump outlet tube to facilitate removal without damaging the O-ring seals.

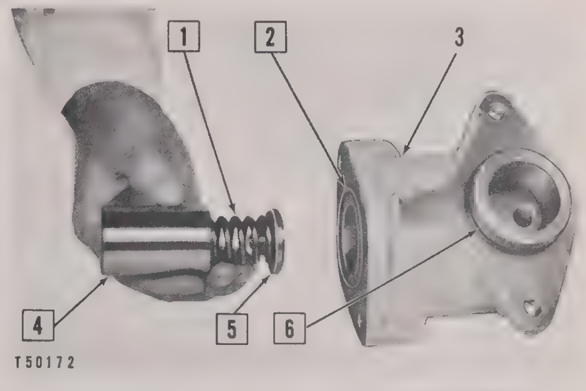


REMOVAL OF THE PRESSURE REGULATING VALVE

Inspect the seals and install in reverse order of removal.

Disassembly and Assembly

Remove the tube assembly and tee from the valve housing **(3)**.



PRESSURE REGULATING VALVE DISASSEMBLY

☐ **Remove**

1–Spring. 2–Seal. 3–Housing. 4–Plunger. 5–Guide. 6–Seal.

While the pressure regulating valve is disassembled, clean the housing **(3)** and before assembling, inspect seals **(2)** and **(6)** for damage and replace if necessary.

Oil Pump

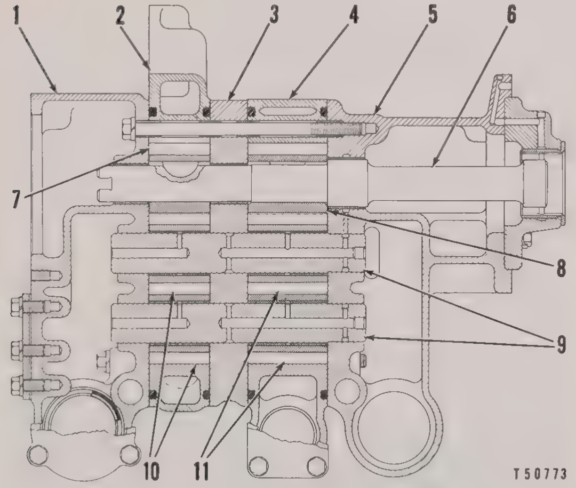
(Two-section Pump)

OPERATION AND LUBRICATION

The oil pump is a two-section, outlet pressure controlled, gear-type pump, driven by an idler gear from the front gear of the crankshaft. Each section of the pump has three gears.

The pump is bolted to the lower right front corner of the engine block.

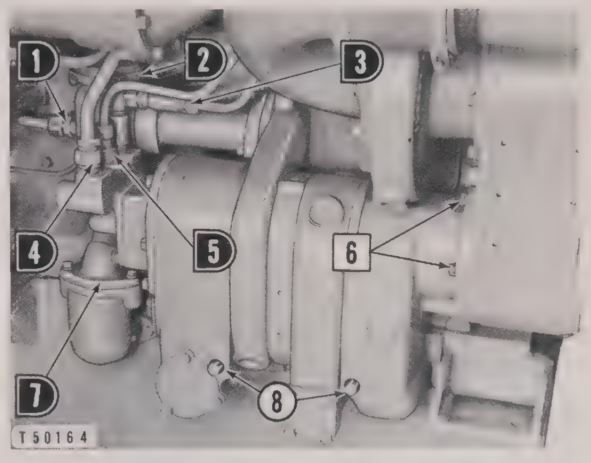
The rear section of the pump draws oil from the main sump of the engine base and delivers it to the engine block for engine lubrication. The pressure regulating valve limits the oil pressure to the main bearings to approximately 45 PSI.



OIL PUMP
1–Main oil pump intake manifold. 2–Main oil pressure manifold. 3–Divider. 4–Scavenge oil pump manifold. 5–Scavenge oil pump intake manifold. 6–Drive shaft. 7–Main oil pump drive gear. 8–Scavenge pump drive gear. 9–Idler shafts. 10–Main oil pump idler gears. 11–Scavenge pump idler gears.

The front section of the pump acts as a scavenge pump. The oil is drawn from the scavenge sumps and is dumped into the engine main sump. The scavenge circuit makes angular operation of the engine possible without danger of starving the lubricating system of oil.

OIL PUMP REMOVAL AND INSTALLATION

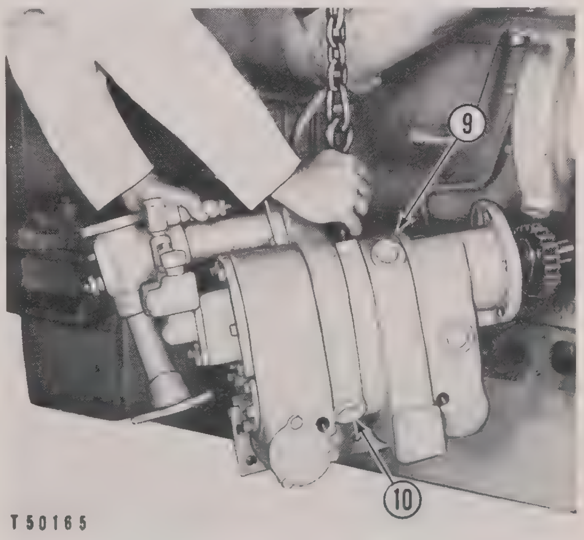


PREPARING TO REMOVE THE OIL PUMP

☐ Remove ■ Disconnect

1–Oil line. 2–Pressure oil pipe connection. 3–Fuel supply line. 4–Fuel return line. 5–Fuel priming pump line. 6–Bolts (six). 7–Pressure oil pipe connection. 8–Bolts (two).

When all lines have been disconnected and the bolts **(6)** removed, support the oil pump assembly with a suitable hoist. Remove the bolts **(8)** and lift the scavenge oil pump **(9)** and main oil pump **(10)** from the engine as a unit.



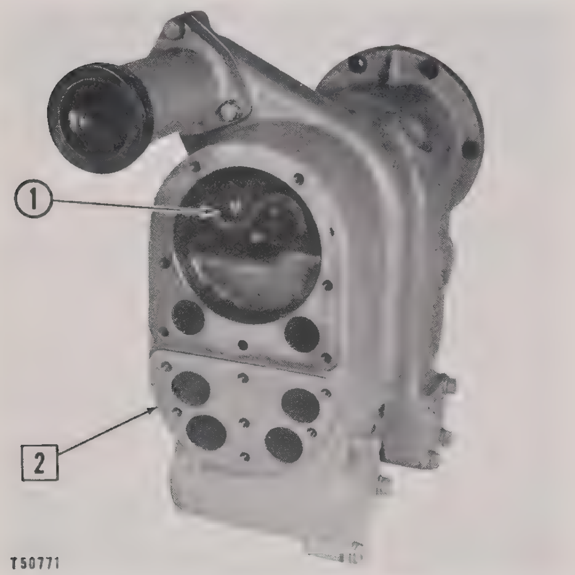
REMOVING OIL PUMP
9–Scavenge oil pump. 10–Main oil pump.

Over

Install in reverse order of removal.

MAIN OIL PUMP DISASSEMBLY AND ASSEMBLY

1. Remove the fuel transfer pump as described in the topic, FUEL TRANSFER PUMP.
2. Remove the cover plate from the back of the oil pump.
3. Remove the nine bolts **(1)** which secure the manifold **(2)** to the pump assembly.

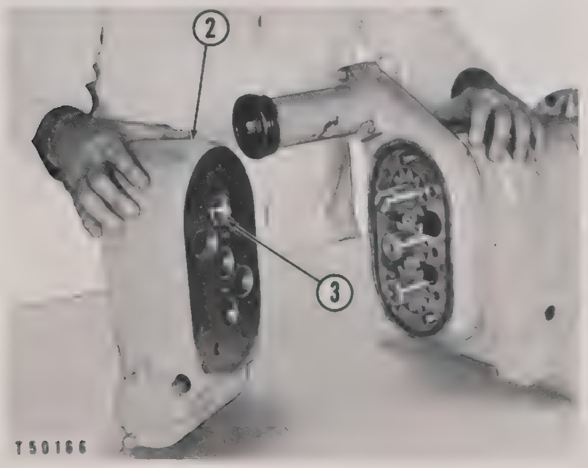


OIL INTAKE MANIFOLD

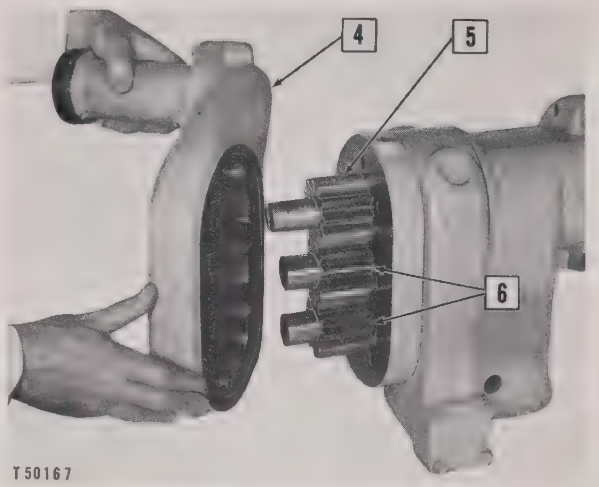
☐ **Remove**

1–Bolt. 2–Oil intake manifold.

4. Inspect the bearing **(3)** and replace if necessary by driving the bearing out of the manifold.



PREPARING TO DISASSEMBLE THE OIL PUMP
2–Oil intake manifold. 3–Drive shaft bearing.



DISASSEMBLING MAIN OIL PUMP

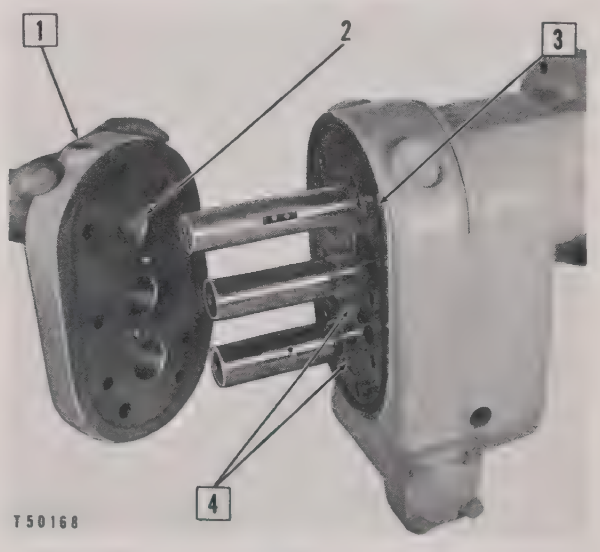
☐ **Remove**

4–Main oil pressure manifold. 5–Drive gear. 6–Idler gears.

NOTE

During assembly, the two longest bolts **(1)** go into the lower two holes in the manifold **(2)**.

SCAVENGE OIL PUMP DISASSEMBLY AND ASSEMBLY



PREPARING TO DISASSEMBLE SCAVENGE OIL PUMP

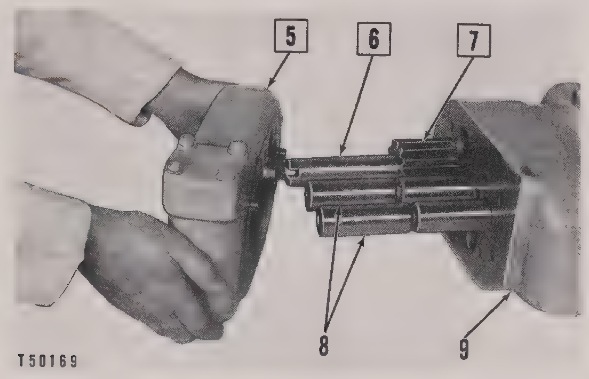
☐ **Remove**

1–Divider. 2–Bearing. 3–O-ring seal. 4–Idler gears.

Inspect bearing **(2)** and replace if necessary.

1. Remove the key from beneath the drive gear **(7)**.
2. The idler shafts **(8)** are pressed into the scavenge oil pump intake manifold **(9)** and can be

removed if necessary. If new shafts (**8**) are to be installed they should be chilled before installation.



SCAVENGE OIL PUMP DISASSEMBLY

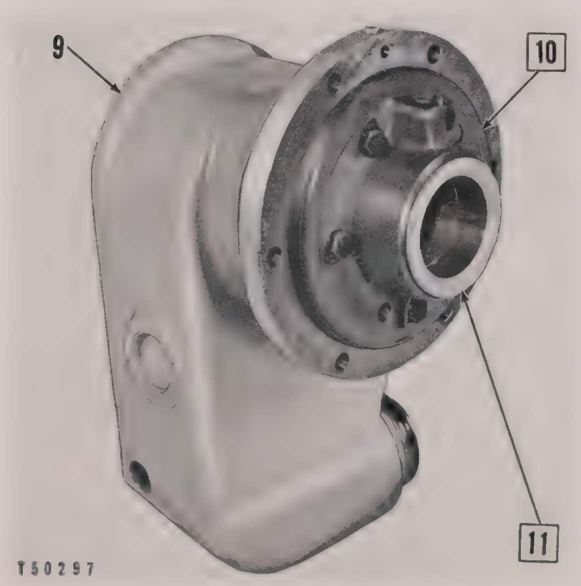
☐ Remove

5–Scavenge oil pump manifold. 6–Drive shaft. 7–Drive gear. 8–Idler shafts. 9–Scavenge oil pump intake manifold.

3. Inspect the bearings at both ends of the oil manifold (**9**).

NOTE

If either bearing (**11**) or the bearing at the other end of the oil manifold (**9**) requires replacement, remove the retainer (**10**) and press out the bearing.



BEARING REMOVAL

☐ Remove

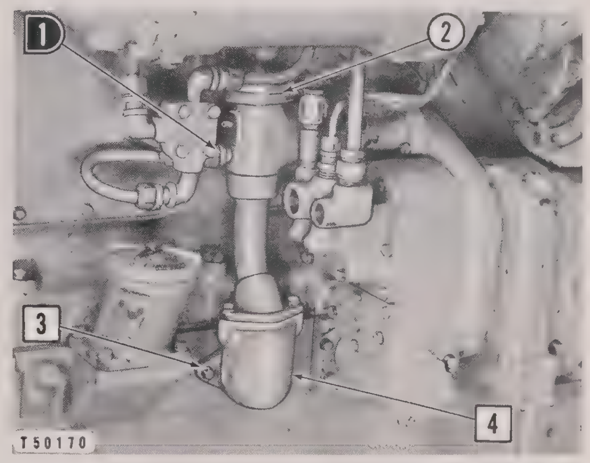
9–Scavenge oil pump intake manifold. 10–Retainer. 11–Bearing.

4. Check all O-ring seals for damage and reassemble in reverse order of disassembly.

PRESSURE REGULATING VALVE

The pressure regulating valve is located directly to the rear of the main oil pump. The valve maintains an oil pressure limit of approximately 45 PSI at the gauge. Excess oil which passes the pressure regulating valve dumps directly into the engine main sump.

Removal and Installation



PREPARING TO REMOVE THE REGULATING VALVE

☐ Remove ◗ Disconnect

1–Oil tube. 2–Flange. 3–Bolts. 4–Regulating valve housing and tube assembly.

Remove the bolts which secure the pipe to the flange (**2**).

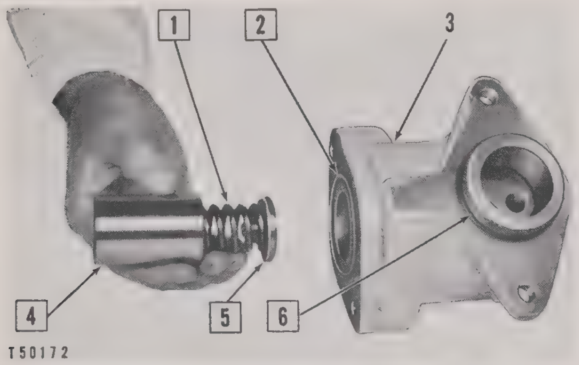
REMOVING PRESSURE REGULATING VALVE

Work the regulator valve housing out of the block and the tube assembly away from the oil pump outlet tube to facilitate removal without damaging the O-ring seals.

Inspect seals and install in reverse order of removal.

Disassembly and Assembly

Remove the tube assembly and tee from the valve housing **(3)**.



PRESSURE REGULATING VALVE DISASSEMBLY

☐ Remove

1–Spring. 2–Seal. 3–Housing. 4–Plunger.
5–Guide. 6–Seal.

While the pressure regulating valve is disassembled, clean the housing **(3)** and before assembling, inspect seals **(2)** and **(6)** for damage and replace if necessary.

INTRODUCTION

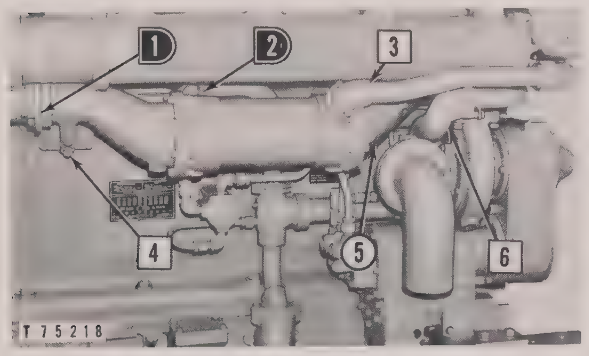
The oil cooler is mounted beneath the inlet manifold on the right side of the engine.

Coolant from the diesel engine cooling system is circulated through the oil cooler and then through the top part of the flywheel housing to the aftercooler prior to entering the cylinder block.

The oil enters the oil cooler at the rear, circulates through the cooler and flows out the top into the filter housing, where it circulates through the filters and enters the oil manifold.

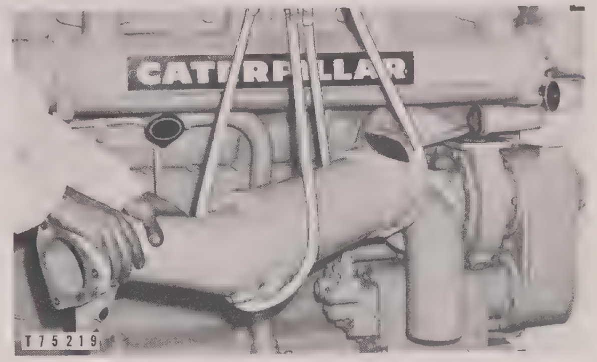
REMOVAL AND INSTALLATION

1. Drain the coolant from the cooling system and oil cooler.
2. Drain the oil from the cooler.



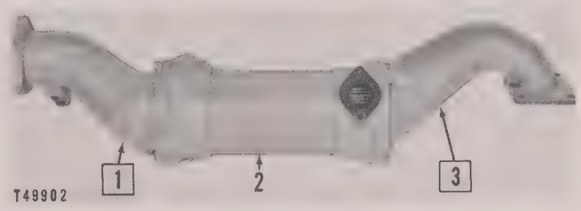
PREPARING TO REMOVE THE OIL COOLER
1–Water outlet pipe. 2–Oil inlet line. 3–Oil outlet line. 4–Nuts (two). 5–Water inlet pipe. 6–Bypass elbow.

3. Disconnect water inlet pipe **(5)** from the water pump.
4. Use a hoist and sling to remove the oil cooler. Approximate weight 85 pounds.



REMOVING THE OIL COOLER

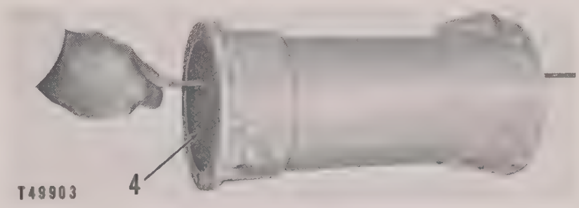
DISASSEMBLY AND ASSEMBLY



OIL COOLER DISASSEMBLY

1–Water outlet pipe. 2–Core assembly. 3–Water inlet pipe.

Clean the water passages in the core **(4)** with a rod 9/32″ in diameter as illustrated.

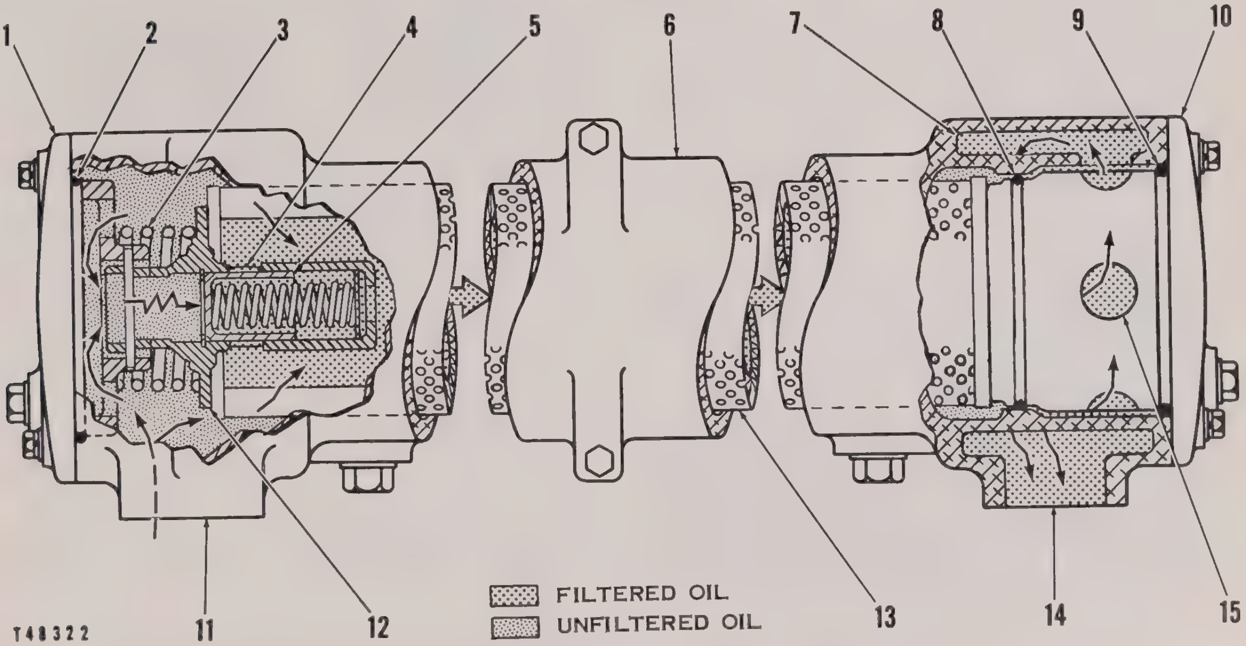


CLEANING THE CORE
4–Core.

Inspect and replace the gaskets, if damaged, before assembling the oil cooler.

Oil Filters

FLOW OF OIL THROUGH OIL FILTER ASSEMBLY



FLOW OF OIL THROUGH OIL FILTER ASSEMBLY

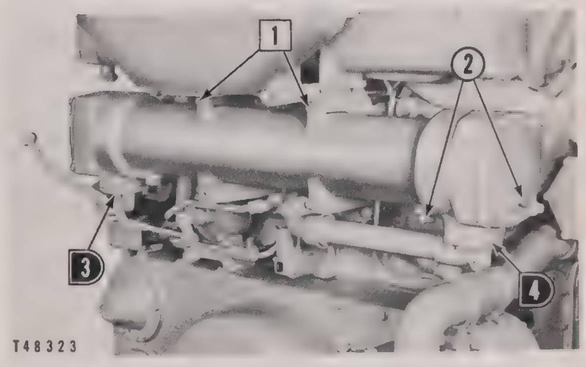
1–Inlet end cover.
2–Seal.
3–Spring.
4–By-pass dump port.
5–Piston.
6–Oil filter housing.
7–Passage.
8–Seal.
9–Seal.
10–Outlet end cover.
11–Inlet port.
12–By-pass housing.
13–Element.
14–Outlet port.
15–Holes.

Unfiltered oil is delivered by the oil pump through the oil cooler to the oil filter inlet port **(11)**. The oil is filtered as it passes through the filter elements **(13)**. The filtered oil passes along the center of the filter elements, through the holes **(15)** in the outlet end cover **(10)**, around the passage **(7)** in the filter housing **(6)** and out the outlet port **(14)** to the engine oil distribution manifold. The O-ring seal **(8)** forms the seal between the filtered and unfiltered oil. The seals **(2)** and **(9)** prevent the escape of oil from the unit. The force of the spring **(3)**, acting against the by-pass housing **(12)**, holds the elements securely, thus forming an effective seal between the various elements and between the end element and outlet end cover **(10)**.

If the oil filter elements should become restricted, excessive pressure will unseat the piston **(5)** in the by-pass housing. This will allow the oil to by-pass the filters, via the dump ports **(4)**, and flow directly to the distribution manifold.

REMOVAL AND INSTALLATION

Drain the oil filter assembly by removing the drain plugs **(2)**.



PREPARING TO REMOVE OIL FILTER ASSEMBLY

1–Bolts (four). 2–Drain plugs. 3–Inlet elbow and bracket assembly. 4–Outlet elbow and bracket assembly.

NOTE

On engines equipped with an expansion tank, remove the coolant tube connecting the base of the expansion tank and the inlet of the water pump.

Remove the oil filter assembly.

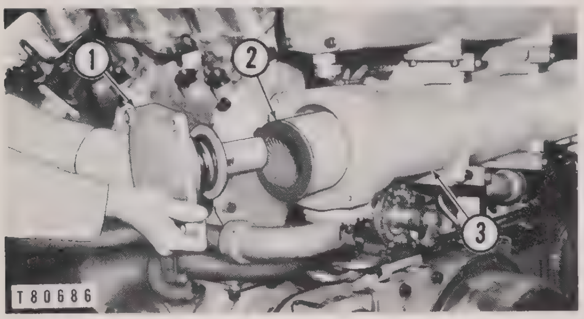
Prior to installation, replace any damaged gaskets or O-ring seals.

DISASSEMBLY AND ASSEMBLY

1. Drain the oil filter assembly by removing the plugs located in the end covers and housing assembly **(3)**.
2. Remove the inlet end cover **(1)**, and then the filter elements **(2)**.

NOTE

Filter elements should be removed only from the inlet end of the filter housing.

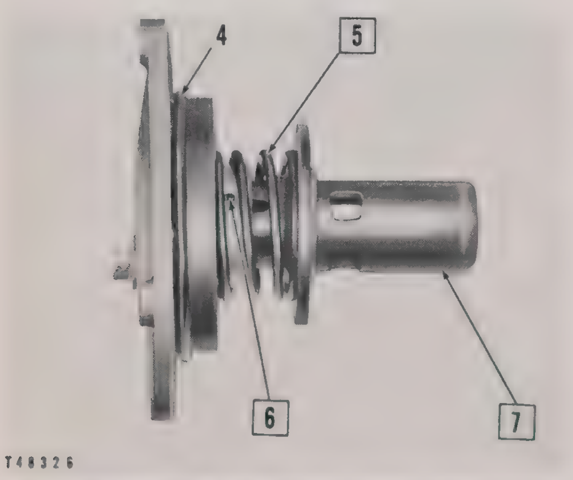


REMOVING INLET END COVER AND BYPASS VALVE
1–Inlet end cover. 2–Filter elements (four). 3–Housing assembly.

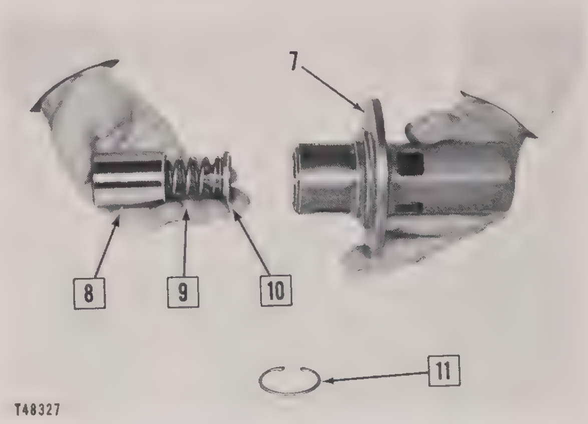
3. Inspect seal **(4)**. Install new seal if necessary.
4. Remove the outlet end cover.
5. Inspect the O-ring seals located on the outlet end cover. Install new seals if necessary.

NOTE

Remove the outlet elbow and pipe first, if the internal passages of housing assembly **(3)** are to be cleaned.



INLET END COVER AND BYPASS VALVE DISASSEMBLY
4–Seal. 5–Spring. 6–Spring pin. 7–Housing.

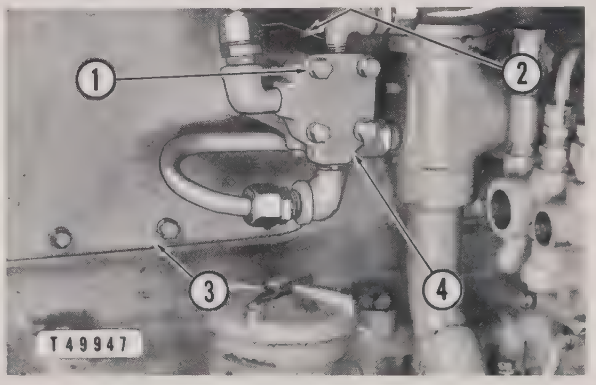


DISASSEMBLING BYPASS VALVE
7–Housing. 8–Plunger. 9–Spring. 10–Guide. 11–Snap ring.

TURBOCHARGER LUBRICATION VALVE REMOVAL AND DISASSEMBLY

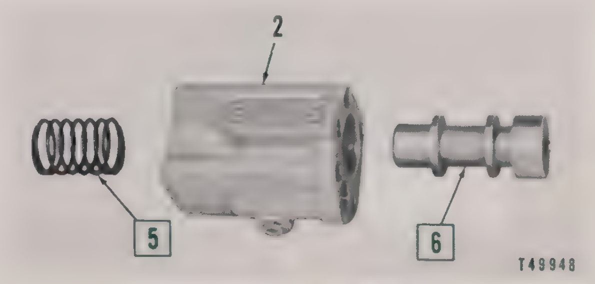
The turbocharger lubrication valve can be removed from the engine without removing the lines.

1. Remove the bolts **(1)** which secure the adapter **(4)** and body **(2)** to the inspection cover **(3)**.
2. Pull the adapter far enough away from the inspection cover to allow the body to be removed.



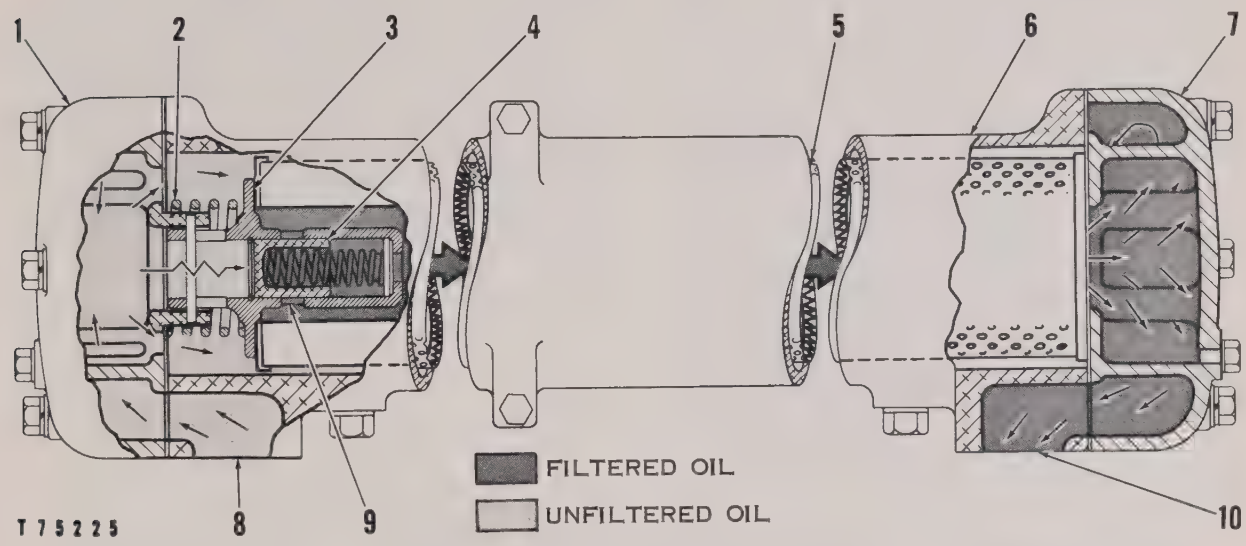
PREPARING TO REMOVE TURBOCHARGER LUBRICATION VALVE
1–Bolts (four). 2–Body. 3–Inspection cover. 4–Adapter.

3. Slide body from between adapter and inspection cover using care not to damage gaskets.
4. Inspect and replace any damaged parts.



VALVE BODY DISASSEMBLY
2–Body. 5–Spring. 6–Plunger.

INTRODUCTION



FLOW OF OIL THROUGH OIL FILTER ASSEMBLY
1–Inlet end cover. 2–Spring. 3–Bypass housing. 4–Valve. 5–Elements (four). 6–Housing. 7–Outlet end cover. 8–Inlet port. 9–Bypass dump port. 10–Outlet port.

Unfiltered oil is delivered by the oil pump through the oil cooler to oil filter inlet port **(8)**. The oil is filtered as it passes through filter elements **(5)**. The filtered oil passes along the center of the filter elements, through openings in outlet end cover **(7)** and out outlet port **(10)** to the engine oil distribution manifold. The force of spring **(2)**, acting against bypass housing **(3)**, holds elements **(5)** securely, thus forming an effective seal between the various elements and between the end element and outlet end cover **(7)**.

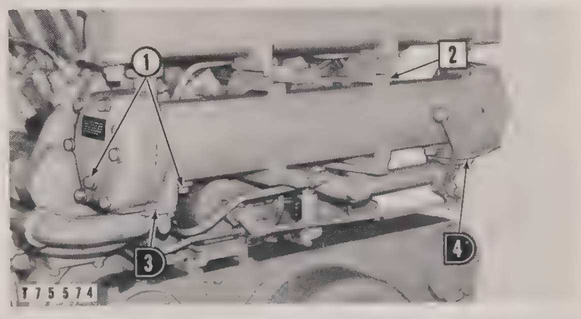
If the oil filter elements should become restricted, excessive pressure will unseat valve **(4)** in the bypass housing. This will allow the oil to bypass the filters, through dump ports **(9)**, and flow directly through the center of the filter elements to end cover **(7)** and out the outlet port to the oil distribution manifold.

REMOVAL AND INSTALLATION

Drain the oil filter assembly by removing drain plugs **(1)**.

NOTE

On engines equipped with an expansion tank, remove the coolant tube connecting the base of the expansion tank and the inlet of the water pump.



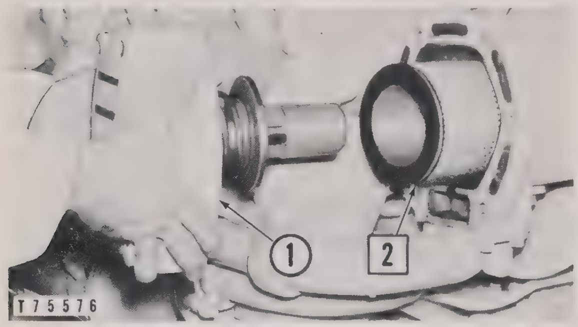
PREPARING TO REMOVE OIL FILTER ASSEMBLY
1–Drain plugs. 2–Bolts (four). 3–Inlet elbow and bracket assembly. 4–Outlet elbow and bracket assembly.

REMOVING OIL FILTER ASSEMBLY

Replace damaged gaskets and O-ring seals.

DISASSEMBLY AND ASSEMBLY

1. Drain the oil filter assembly by removing the plug located in end cover **(1)** and the plug located in the underside of housing.



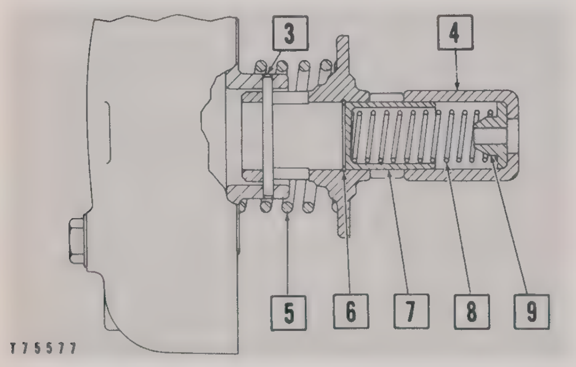
PREPARING TO REMOVE FILTER ELEMENTS
1–Inlet end cover. 2–Filter elements (four).

2. Remove inlet end cover **(1)** to gain access to the filter elements **(2)**.

NOTE

To prevent the possibility of unfiltered oil and sludge from entering the outlet port, remove the outlet elbow and bracket assembly from under the left side of the oil filter assembly prior to removing the outlet end cover.

3. Remove the outlet end cover.



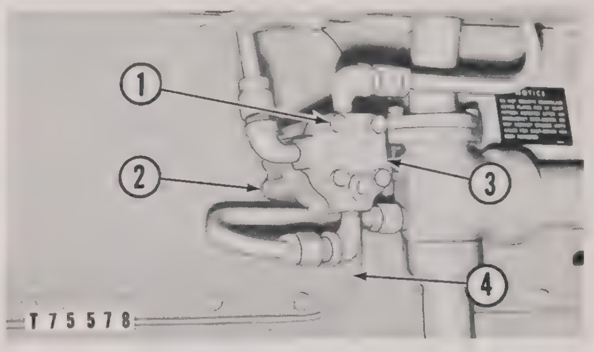
PREPARING TO DISASSEMBLE BYPASS VALVE
3–Pin. 4–Housing. 5–Spring. 6–Snap ring. 7–Valve. 8–Spring. 9–Guide.

4. Inspect all gaskets. Install new gaskets if necessary.

TURBOCHARGER LUBRICATION VALVE

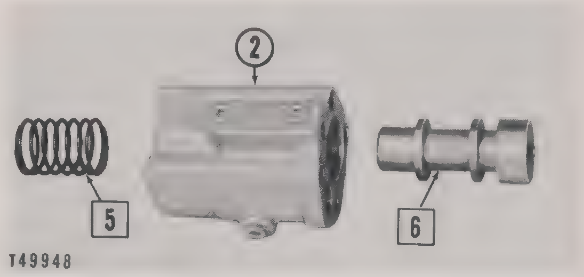
Removal and Disassembly

The turbocharger lubrication valve body can be removed from the engine without removing the lines.



PREPARING TO REMOVE TURBOCHARGER LUBRICATION VALVE
1–Bolts (four). 2–Body. 3–Adapter. 4–Inspection cover.

1. Remove bolts **(1)** which secure adapter **(3)** and body **(2)** to inspection cover **(4)**.
2. Pull the adapter far enough away from the inspection cover to allow the body to be removed.
3. Slide the body out from between the adapter and inspection cover using care not to damage the gaskets.



VALVE BODY DISASSEMBLY
2–Body. 5–Spring. 6–Plunger.

4. Install new parts if necessary.

Sump Pump

Normally, marine engine installations are made in surroundings that offer only limited clearance beneath the engine oil pan. This makes it difficult in most cases, and impossible in other cases, to drain the oil by removing the drain plug in the bottom of the engine base.

A hand-operated sump pump, which can be mounted either remotely or on the engine and connected to the sump by means of flexible hoses, provides a method of removing oil from the engine base and/or marine gear, if so equipped.

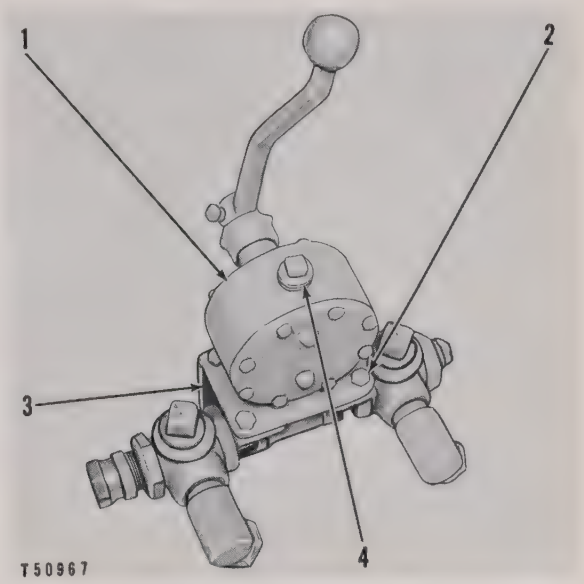
The pump is a wobble type pump that will deliver six gallons per minute when pumped 60 strokes per minute.

REMOVAL AND INSTALLATION

Disconnect the lines to the pump from the oil pan and marine gear and the outlet line from the pump. Protect these openings from the entry of dirt or other foreign material by use of caps or plugs such as plug **(4)** in the pump outlet port.

Remove the four bolts **(2)** which secure the sump pump **(1)** to the mounting bracket **(3)**.

Inspect the parts for wear and damage and replace if necessary.



REMOVING THE SUMP PUMP
1–Sump pump. 2–Bolts. 3–Mounting bracket. 4–Plug.

DISASSEMBLY AND ASSEMBLY

Since a pump of the same design is used for a fuel priming pump, refer to the topic, FUEL PRIMING PUMP, for information on disassembly and assembly.

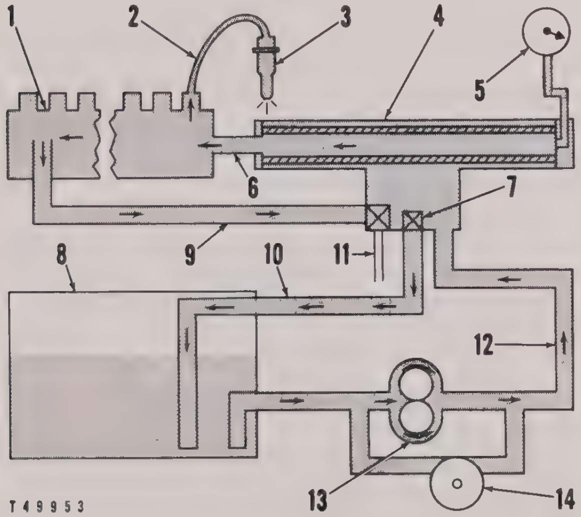
Fuel System

OPERATION

Fuel for the diesel engine is drawn from the fuel supply tank **(8)** by the fuel transfer pump **(13)**.

The fuel transfer pump delivers fuel through line **(12)** to the fuel filter housing **(4)** and forces fuel through the filter elements. A by-pass valve **(7)** located in the fuel filter housing maintains approximately 15 pounds of pressure on the fuel in the filter housing. Excess fuel supplied by the transfer pump is returned to the supply tank through line **(10)**.

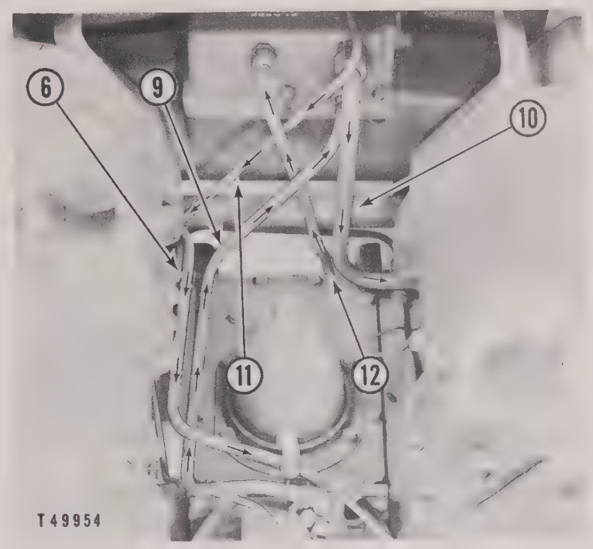
Fuel passing through the fuel filters is directed to the fuel manifold located in the fuel pump housing by line **(6)**. The fuel manifold distributes the fuel to the individual fuel injection pumps.



FUEL SYSTEM (SCHEMATIC)

1–Fuel injection pump housing.
2–Injection line.
3–Injection valve.
4–Fuel filter housing.
5–Fuel pressure gauge.
6–Injection pump supply line.
7–By-pass valve.
8–Fuel supply tank.
9–Bleed line.
10–Return line.
11–Vent line.
12–Fuel supply line.
13–Fuel transfer pump.
14–Priming pump.

The cam-actuated injection pumps force a measured quantity of fuel under high pressure through injection lines **(2)** to the injection valves **(3)**. The single orifice injection valves spray fuel into the combustion chamber where it is burned.



FUEL LINES
6–Injection pump supply line. 9–Bleed line. 10–Return line. 11–Vent line. 12–Fuel supply line.

A hand-operated fuel priming pump **(14)** is used, when necessary, to assure that the fuel in the fuel manifold is under pressure and free of air at the time of starting. Air is bled from the fuel system through a bleeder valve. When the valve is open, any air in the fuel lines, fuel filter housing, or bleeder manifold is discharged through the vent line **(11)**. For priming and air bleeding procedures, see the covering topic in the OPERATION AND MAINTENANCE INSTRUCTIONS.

A pressure gauge **(5)** indicates the fuel pressure on the supply side of the fuel injection pump housing.

Lack of pressure on the gauge indicates difficulty in the supply side of the system. This could be caused by an empty diesel fuel tank, closed shut-off valve at the tank, clogged filters, dirt under the by-pass valve, open vent valve, a faulty transfer pump or gauge.

Air in the system or water in the fuel can also be responsible for the engine firing irregularly or failing to start.

If, after eliminating the above possibilities, there still seems to be something wrong with the fuel system, check the injection side of the system. Fuel injection pumps and fuel injection valves can be checked as described in the topic, FUEL INJECTION EQUIPMENT.

Many times the fuel system is blamed when the fault lies elsewhere. A smoky exhaust may be caused by faulty fuel injection valves. But it can also be caused by dirty air cleaners, overloading at high altitudes or badly worn piston rings.

Irregular firing can be caused by faulty fuel injection valves. It can also be caused by the burning of excessive lubricating oil escaping past worn piston rings, or new rings which have not become fully seated.

Fuel Supply Equipment

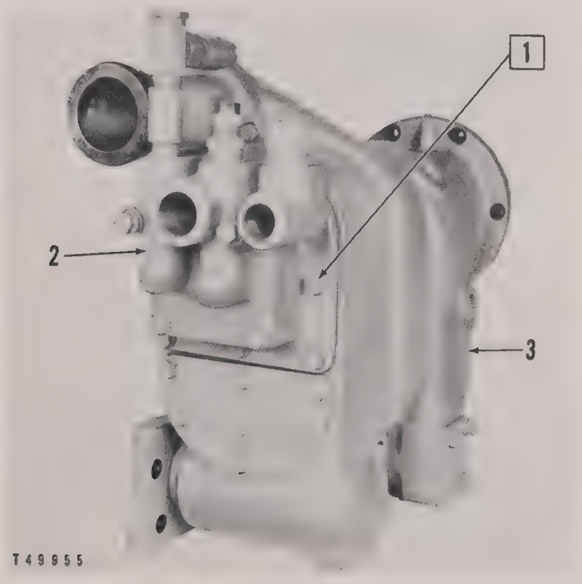
FUEL TRANSFER PUMP

The fuel transfer pump is used to pump fuel from the main supply tank, through the fuel filter and on into the fuel injection pump housing. The fuel transfer pump mounts on the oil pump housing, and drives from the oil pump drive shaft. The fuel transfer pump may be removed or installed with the oil pump either mounted on the engine or removed from it.

Removal and Installation

If the oil pump is mounted on the engine, drain the fuel filter housing and disconnect the fuel lines at the fuel transfer pump **(2)**.

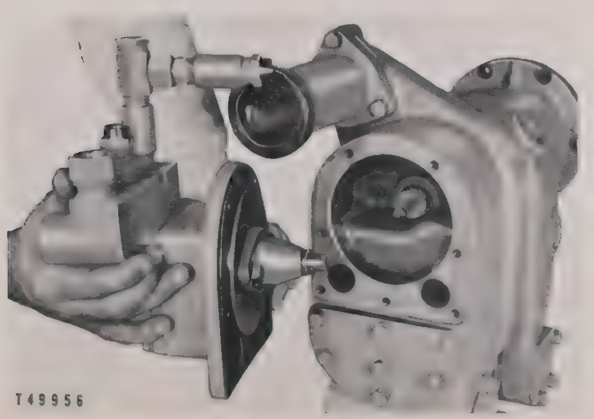
Remove the fuel transfer pump **(2)** from the oil pump **(3)** as illustrated.



PREPARING TO REMOVE THE FUEL TRANSFER PUMP

☐ **Remove**

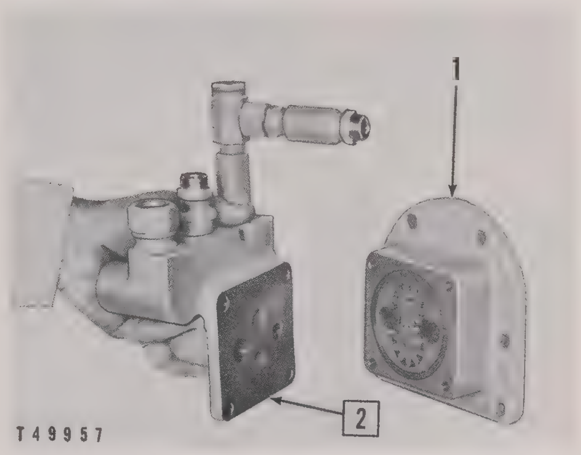
1–Bolts. 2–Fuel transfer pump. 3–Oil pump.



FUEL TRANSFER PUMP REMOVAL

Inspect and replace any damaged parts.

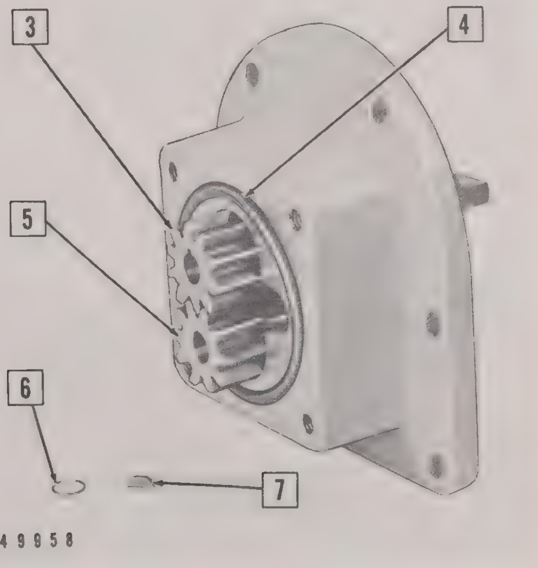
Disassembly and Assembly



COVER REMOVAL

☐ **Remove**

1–Transfer pump body. 2–Cover.



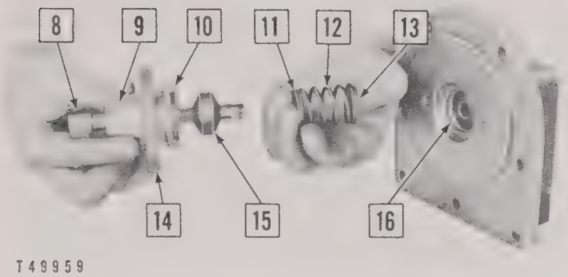
DISASSEMBLING PUMP BODY

☐ **Remove**

3–Drive gear. 4–O-ring seal. 5–Idler gear. 6–Lock ring. 7–Key.

The shaft which supports the idler gear **(5)** is pressed into the pump body and can be removed if necessary.

Inspect the bearings in the seat assembly **(9)** and the transfer pump body **(1)** and replace if necessary. When installing the bearings, place the tapered edge toward the seals.



PUMP DRIVE SHAFT DISASSEMBLY

☐ Remove

8–Drive shaft. 9–Seat assembly. 10–Gasket. 11–Retainer. 12–Spring. 13–Retainer. 14–Flange. 15–Seal. 16–Seal and gasket.

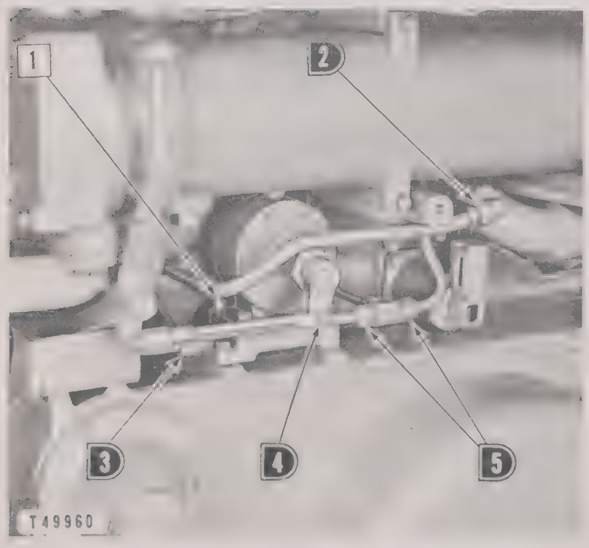
Replace any worn or damaged seals and install in reverse order of removal.

FUEL PRIMING PUMP

The wobble-type priming pump is located on top of the front accessory drive housing. The needle valve used for bleeding the entire fuel system is located on top of the fuel filter housing. The glass window in the housing at the bleeder valve enables the operator to observe air bubbles when bleeding the system.

For instructions on priming the engine, consult the Operation and Maintenance Instructions.

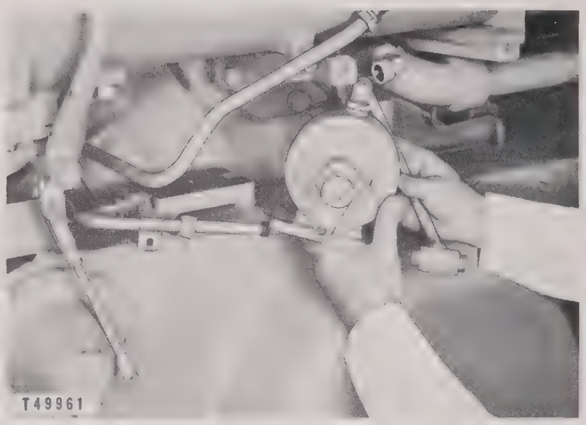
Removal and Installation



PREPARING TO REMOVE FUEL PRIMING PUMP

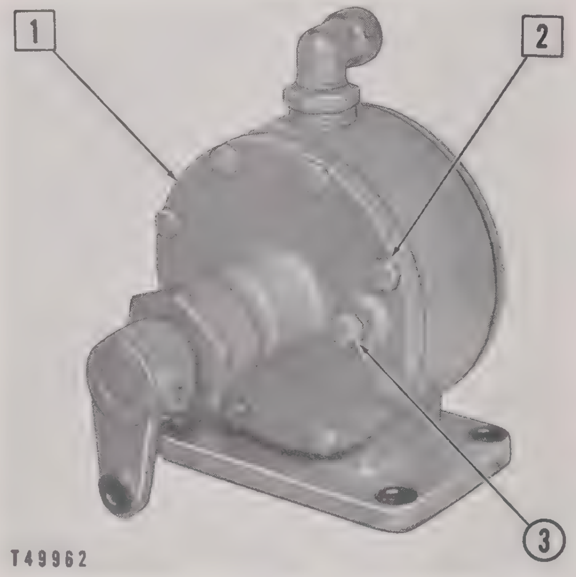
☐ Remove ◗ Disconnect

1–Bolts. 2–Oil line. 3–Fuel line. 4–Rod. 5–Fuel lines.



REMOVING THE FUEL PRIMING PUMP

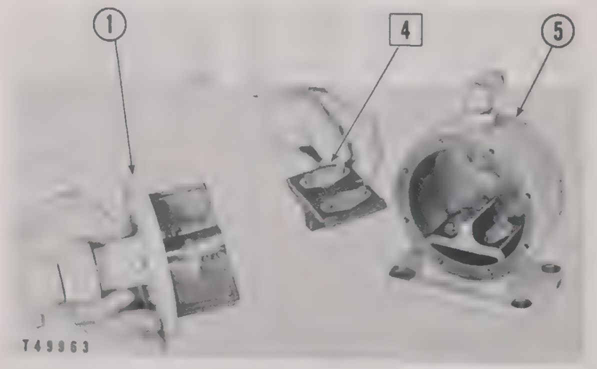
Disassembly



PREPARING TO DISASSEMBLE FUEL PRIMING PUMP

☐ Remove

1–Front lid assembly. 2–Bolts. 3–Plug.



DISASSEMBLY OF FUEL PRIMING PUMP

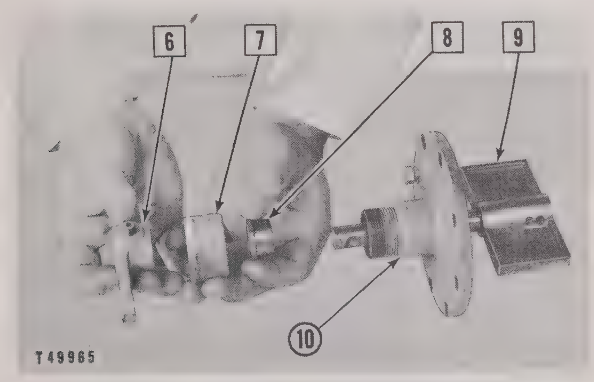
☐ Remove

1–Front lid assembly. 4–Upper deck. 5–Cylinder.

The lower deck can also be removed from the cylinder.

NOTE

If the priming pump has not been used for an extended period of time, it may be necessary to prime the pump before it can be used. This can be done by removing the priming plug **(3)** and pouring a small amount of fuel in the pump.



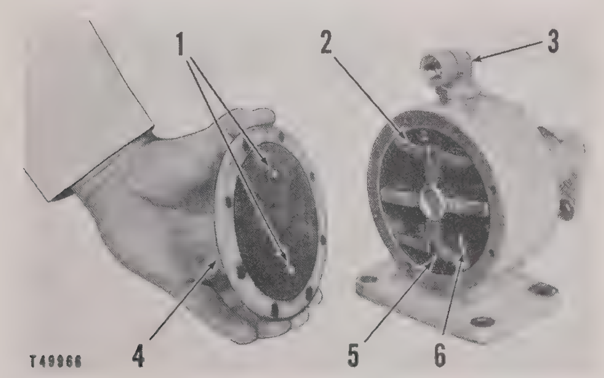
DISASSEMBLY OF LID ASSEMBLY

☐ Remove

6–Lever. 7–Nut. 8–Gland. 9–Wing and shaft. 10–Lid.

Inspect the packing in the lid **(10)** and replace if necessary.

Assembly



PRIMING PUMP ASSEMBLY
1–Dowels. 2–Outlet deck. 3–Outlet port. 4–Rear lid. 5–Inlet deck. 6–Plungers.

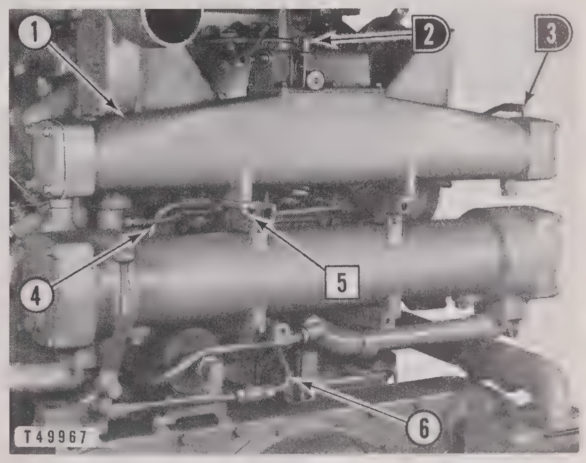
Assemble in reverse order of disassembly. The inlet or lower deck **(5)** and the outlet or upper deck **(2)** must be replaced in their original position, with the valve plungers **(6)** toward the outlet port **(3)**. The inlet and outlet decks are held in place by two dowels **(1)** located in the pump rear lid **(4)**.

The end clearance of the pump is controlled by adding or removing gaskets between the pump cylinder and the front lid.

FUEL FILTER

Removal and Installation

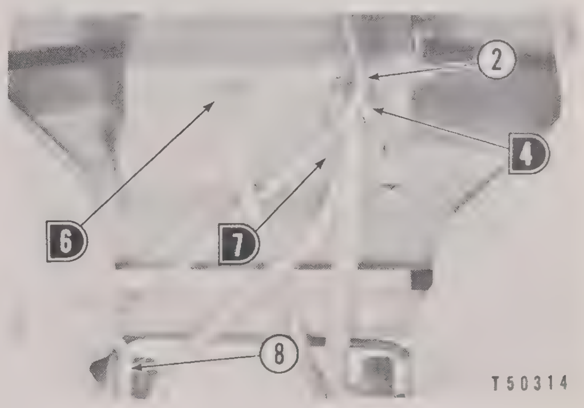
Drain the fuel from the fuel filter housing.



PREPARING TO REMOVE THE FUEL FILTER

☐ Remove ◗ Disconnect

1–Fuel filter housing. 2–Vent tube. 3–Pressure gauge line. 4–Fuel return line. 5–Bolts. 6–Fuel supply line.



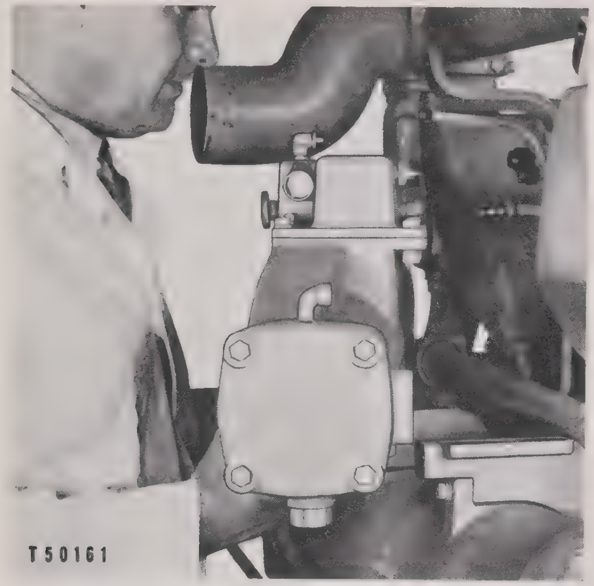
DISCONNECTING FUEL LINES
(Top Rear View of Fuel Filter Lines)

◗ Disconnect

2–Vent tube. 4–Fuel return line. 6–Fuel supply line. 7–Bleed line. 8–Injection pump supply line.

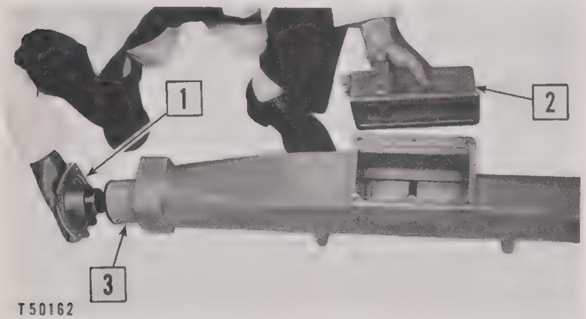
Disconnect the injection pump supply line **(8)** at the left end of the fuel filter housing **(1)**.

Replace any damaged parts and install in reverse order of removal.



REMOVING THE FUEL FILTER

Disassembly and Assembly



FILTER DISASSEMBLY

☐ Remove

1–Cover. 2–By-pass valve housing. 3–Filter elements.

The six filter elements **(3)** can be removed from either end of the fuel filter housing.

The spring can be removed and replaced from the right end cover if necessary.

Inspect the gaskets and seal and replace if damaged.

FUEL BY-PASS

Since the transfer pump normally pumps more fuel than is required by the engine, a by-pass for the excess fuel is provided.

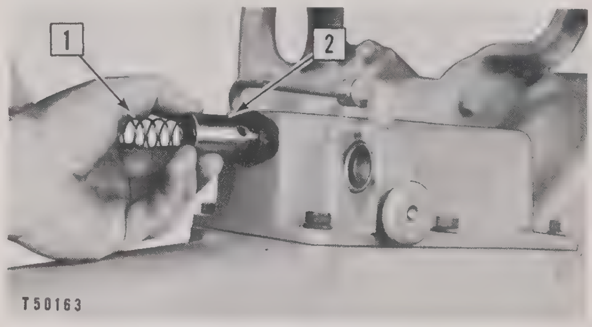
This assembly regulates the fuel pressure to the fuel injection pumps. The plunger opens when the fuel injection pumps do not use all the fuel. The spring pressure is such that the excess fuel is by-passed to the tank without causing damage to the fuel filter housing or fuel filter pressure gauge mechanism.

The plunger may fail to function properly if dirt gets between the seat and the plunger. This may cause the fuel filter pressure gauge needle to show a wide variation between low idle and high idle speed. After cleaning the contact surfaces, see that the seat is smooth and flat and that the sealing surface of the plunger is in good condition.

Removal and Installation

It is not necessary to remove the by-pass valve housing from the fuel filter housing to remove the by-pass valve.

Remove the cover which bolts to the right end of the by-pass valve housing.



REMOVING BY-PASS VALVE

☐ Remove

1–Spring. 2–Plunger.

Inspect the plunger and plunger seat for burrs, foreign material, and seat finish. Clean if necessary.

Install in reverse order of removal making sure the spring **(1)** and plunger **(2)** are properly seated.

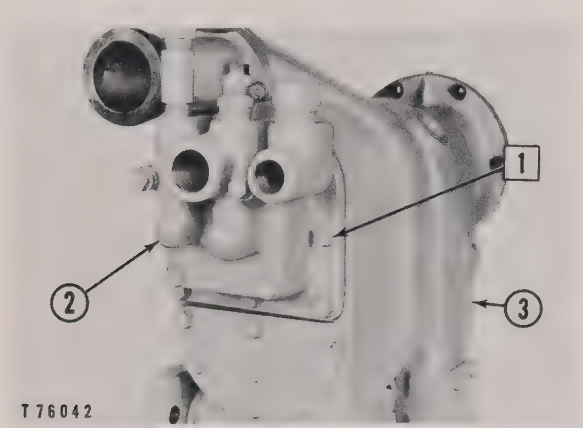
FUEL TRANSFER PUMP

The fuel transfer pump delivers the fuel from the main supply tank, through the fuel filter to the fuel injection pump housing. The fuel transfer pump mounts on the oil pump housing, and is driven by the oil pump drive shaft. The fuel transfer pump can be removed and installed when the oil pump is either mounted on the engine or removed from it.

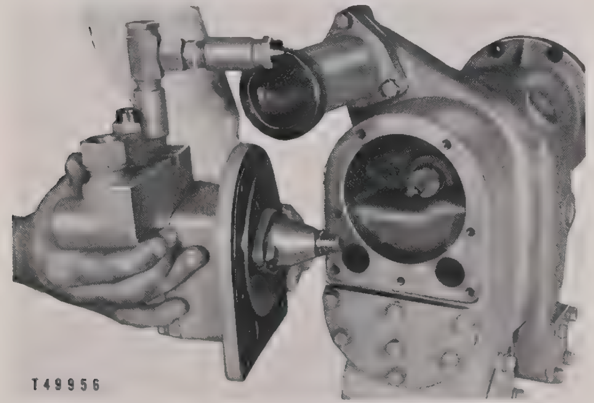
Removal and Installation

If the oil pump is mounted on the engine, drain the fuel filter housing and disconnect the fuel lines at fuel transfer pump **(2)**.

Remove fuel transfer pump **(2)** from oil pump **(3)**.



PREPARING TO REMOVE THE FUEL TRANSFER PUMP
1–Bolts (seven). 2–Fuel transfer pump. 3–Oil pump.

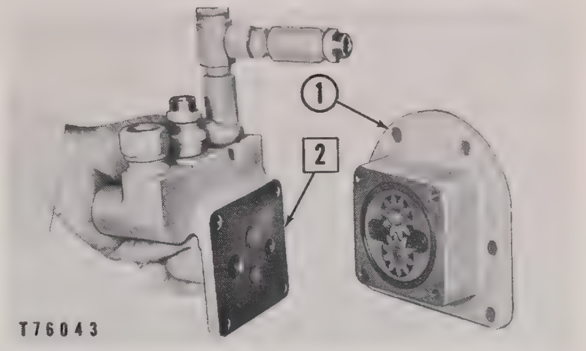


FUEL TRANSFER PUMP REMOVAL

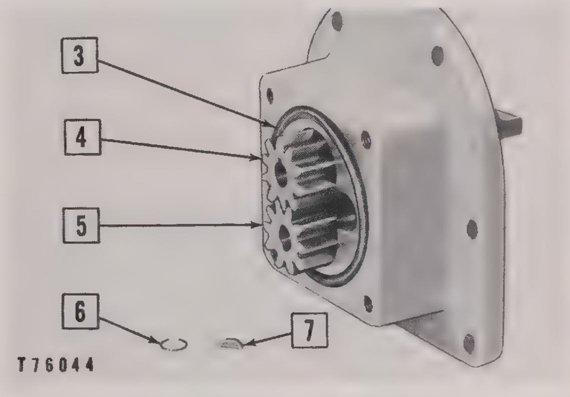
Disassembly and Assembly

The shaft supporting idler gear **(5)** is pressed into the pump body and can be removed.

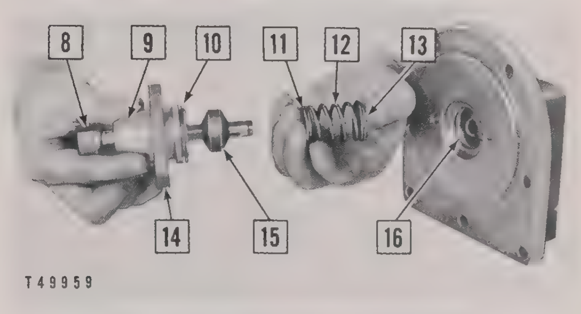
Replace the bearings in seat assembly **(9)** and transfer pump body **(1)** if necessary. Install the bearings with the tapered edge toward the seals.



COVER REMOVAL
1–Transfer pump body. 2–Cover.



DISASSEMBLING PUMP BODY
3–O-ring seal. 4–Drive gear. 5–Idler gear. 6–Lock ring. 7–Key.



PUMP DRIVE SHAFT DISASSEMBLY
8–Drive shaft. 9–Seat assembly. 10–Gasket. 11–Retainer. 12–Spring. 13–Retainer. 14–Flange. 15–Seal. 16–Seal and gasket.

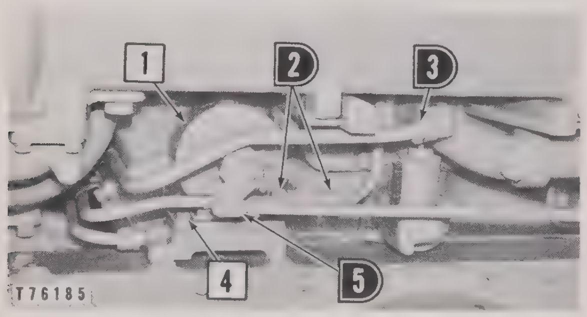
Replace any worn or damaged seals and install in reverse order of removal.

FUEL PRIMING PUMP

The wobble-type priming pump is located on top of the front accessory drive housing. The needle valve for bleeding the entire fuel system is on top of the fuel filter housing. When bleeding the system, the glass window in the housing enables the operator to see when the fuel is free of air bubbles.

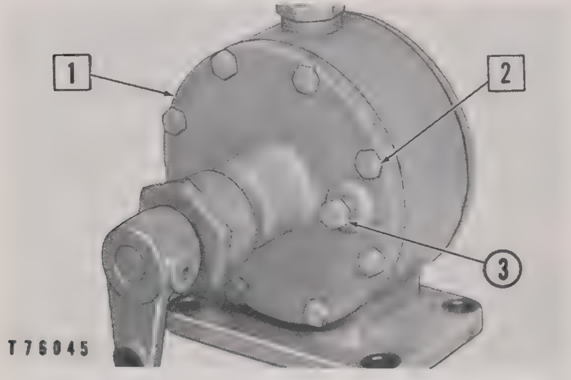
For instructions on priming the engine, consult the Operation and Maintenance Instructions.

Removal and Installation

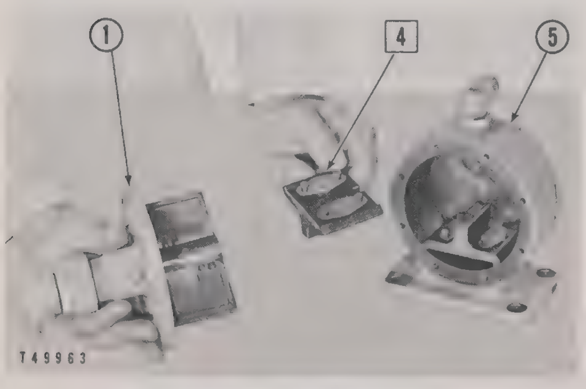


PREPARING TO REMOVE FUEL PRIMING PUMP
1–Priming pump. 2–Fuel lines. 3–Oil line. 4–Bolts (four). 5–Rod.

Disassembly



PREPARING TO DISASSEMBLE FUEL PRIMING PUMP
1–Front lid assembly. 2–Bolts. 3–Plug.

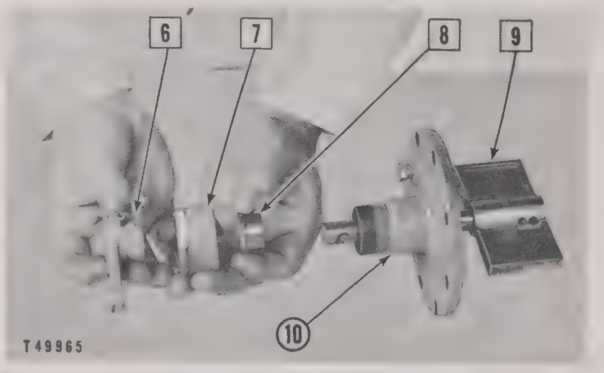


DISASSEMBLY OF FUEL PRIMING PUMP
1–Front lid assembly. 4–Outlet deck. 5–Cylinder.

The inlet deck can also be removed from the cylinder.

NOTE

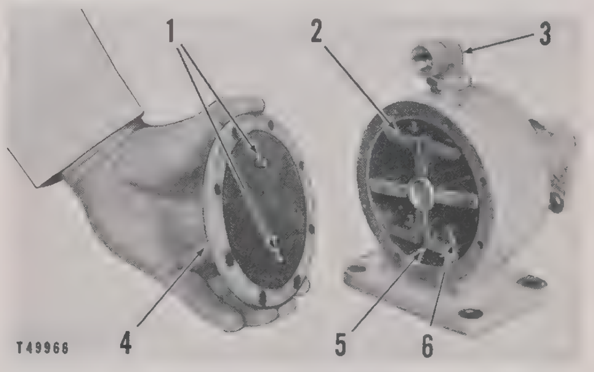
If it is necessary to prime the pump, remove priming plug **(3)**, pour fuel in the pump and install the plug.



DISASSEMBLY OF LID ASSEMBLY
6–Lever. 7–Nut. 8–Gland. 9–Wing and shaft. 10–Lid.

Replace the packing in lid **(10)** if necessary.

Assembly



PRIMING PUMP ASSEMBLY
1–Dowels. 2–Outlet deck. 3–Outlet port. 4–Rear lid. 5–Inlet deck. 6–Plungers.

Assemble in reverse order of disassembly. Inlet deck **(5)** and outlet deck **(2)** must be replaced in their original position, with valve plungers **(6)** toward outlet port **(3)**. The inlet and outlet decks are held in place by two dowels **(1)** in rear lid **(4)**.

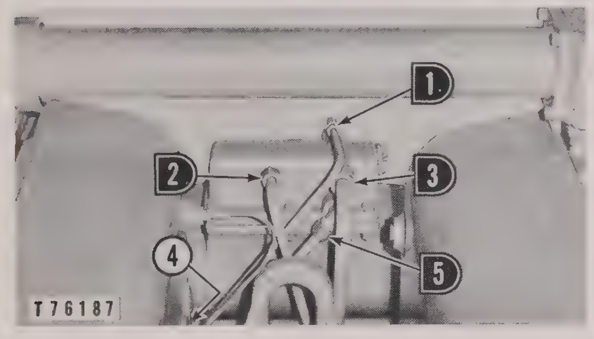
The end clearance of the pump is controlled by adding or removing gaskets between the pump cylinder and the front lid.

FUEL FILTER

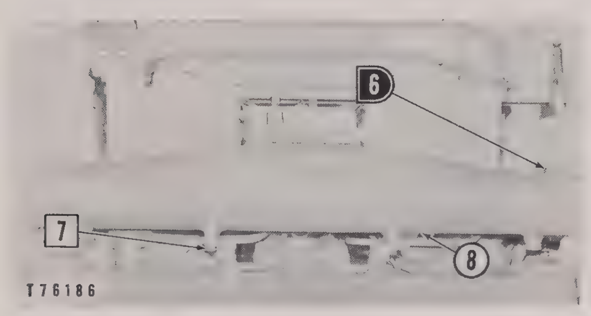
Removal and Installation

Drain the fuel from the fuel filter housing.

Disconnect the injection pump supply line **(4)** at the left end of fuel filter housing **(8)**.



DISCONNECTING FUEL LINES
(Top Rear View of Fuel Filter Housing)
1–Vent tube. 2–Fuel supply line. 3–Fuel return line. 4–Injection pump supply line. 5–Bleed line.

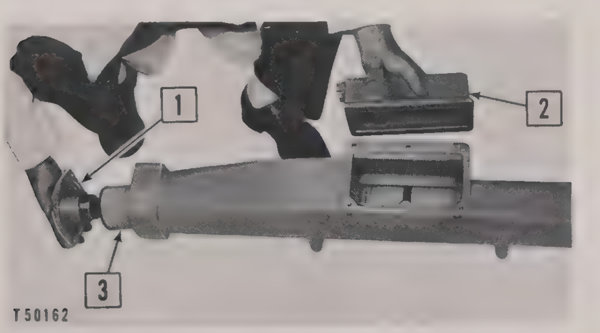


PREPARING TO REMOVE FUEL FILTER HOUSING
6–Pressure gauge line. 7–Bolts (four). 8–Fuel filter housing.

REMOVING THE FUEL FILTER

Replace any damaged parts and install in reverse order of removal.

Disassembly and Assembly



FILTER DISASSEMBLY
1–Cover. 2–Bypass valve housing. 3–Filter elements (six).

Remove filter elements **(3)** from either end of the fuel filter housing.

The spring from the right end cover can be replaced if necessary.

Replace the gaskets and seal, if damaged.

FUEL BYPASS VALVE

The bypass valve regulates the pressure of the fuel to the fuel injection pumps, because the transfer pump normally pumps more fuel than the engine can use.

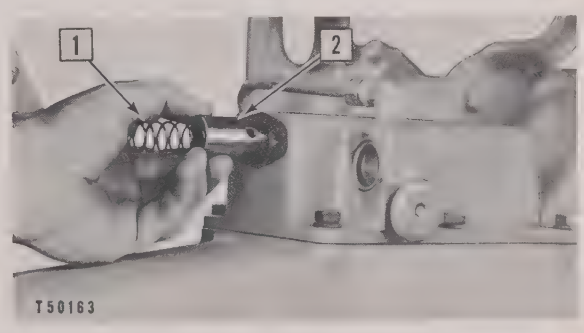
When the oversupply of fuel builds up to a pressure that exceeds the spring force on the bypass valve plunger, the valve will open to regulate the pressure of the fuel to the fuel injection pumps. The fuel that passes through the open bypass valve returns to the fuel supply tank.

A sticking plunger can cause damaging high fuel pressure, or not enough fuel pressure to operate the engine.

Removal and Installation

It is not necessary to remove the bypass valve housing from the fuel filter housing to remove the bypass valve spring and plunger.

Remove the cover which bolts to the right end of the bypass valve housing.



REMOVING BYPASS VALVE
1–Spring. 2–Plunger.

Inspect the plunger and plunger seat for burrs, foreign material, and seat finish. Clean if necessary.

Install in reverse order of removal making sure the spring **(1)** and plunger **(2)** are seated properly.

Fuel Injection Equipment

The most likely causes for faulty fuel injection performance are:

1. Air in the fuel system.
2. Low fuel supply.
3. Water in the fuel.
4. Clogged fuel filters.
5. Insufficient fuel transfer pump pressure.

If these conditions are checked and corrected and the engine still does not perform properly, the fuel injection equipment should be checked.

CHECKING FUEL INJECTION EQUIPMENT

Before removing a fuel injection pump or valve for testing from an engine that is missing or puffing black smoke at the exhaust, a simple check can be made to determine which cylinder is causing the difficulty. With the engine running at a speed which makes the defect most pronounced, momentarily loosen the fuel line nut on the injection pump sufficiently to cut out the cylinder. Check each cylinder in the same manner. If one is found where loosening makes no difference in the irregular operation of the engine or causes puffing of black smoke at exhaust to cease, probably the pump and valve, for only that cylinder, need be tested.

FUEL INJECTION VALVE

The function of the fuel injection valves is to inject and atomize the fuel from the fuel injection pumps into the precombustion chambers. Irregular engine operation and smoking may be caused by an improperly operating injection valve.

The fuel injection valve is installed in the precombustion chamber.

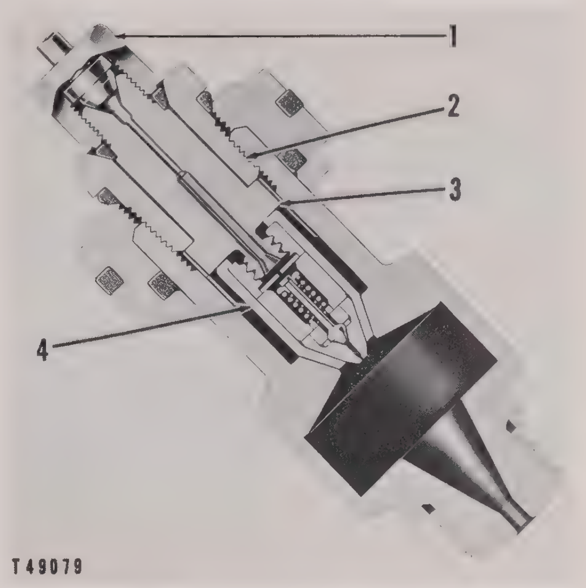
The fuel injection valve assembly consists of the body **(3)**, nut **(2)**, and the capsule-type nozzle assembly **(4)**.

Only the nozzle assembly need be replaced.

The nozzle assembly **(4)** and body **(3)** are held in place by the nut **(2)**, and they can be removed by disconnecting the fuel line assembly **(1)** and removing the nut and seal.

The body and the nozzle assembly can then be lifted out. The nozzle assembly is only finger-tight on the body.

When installing a fuel injection valve, always check the seats of both the nozzle and the precombustion chamber.



FUEL INJECTION VALVE CROSS-SECTION
1–Fuel line assembly. 2–Nut. 3–Body. 4–Nozzle assembly.

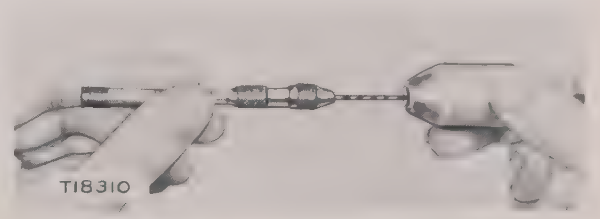
Tighten the nut **(2)** to the torque value given in the topic, SPECIFICATIONS. Excessive tightness will damage the nozzle. Excessive looseness will allow the nozzle to leak and in some instances cause the nozzle case to bulge or split.

Cleaning Fuel Injection Valve

The operation of the engine will be affected if the orifice in the nozzle becomes partially filled with carbon. To correct this, remove the nozzle assembly from the valve body and clean the fuel discharge hole using the drill listed in the topic, SPECIFICATIONS, and a 5B1254 Chuck which are part of the 5B1401 Cleaning Tool Group. If after cleaning, the valve does not operate properly, the nozzle should be checked for leakage.

CAUTION

Do not attempt to clean the carbon from the end of the injection nozzle with a wire brush or wheel. The only maintenance required on the injection nozzle is to clean the fuel discharge hole using the correct size drill as indicated



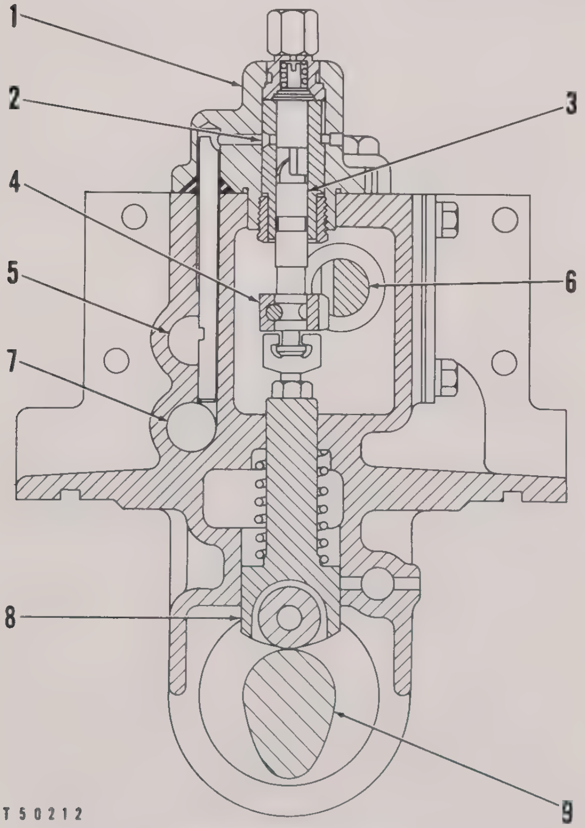
CLEANING FUEL INJECTION NOZZLE ASSEMBLY

Checking Fuel Injection Valve

The condition of a capsule type nozzle assembly can be tested out of the engine on the Caterpillar Diesel Fuel Injection Test Apparatus. The spray characteristic, valve unseating pressure, and the rate of leakage of the nozzle assembly can be determined.

FUEL INJECTION PUMPS

Air in the fuel system is bled through the bleeder manifold **(5)** when the bleeder valve is opened and fuel enters the bleeder manifold through passage **(7)**. The injection pump plungers **(3)** and the lifters **(8)** are lifted by cams on the camshaft **(9)** and always make a full stroke. Each pump **(1)** measures the amount of fuel to be injected into its respective cylinder and delivers it to the fuel injection valve.



FUEL INJECTION PUMP
1–Pump. 2–Inlet port. 3–Pump plunger. 4–Gear segment. 5–Bleeder manifold. 6–Rack. 7–Fuel passage. 8–Lifter. 9–Camshaft.

The amount of fuel pumped per stroke can be varied by turning the plunger in the barrel. The plunger is turned by the governor action through the rack **(6)** which meshes with the gear segment **(4)** on the bottom of the pump plunger.

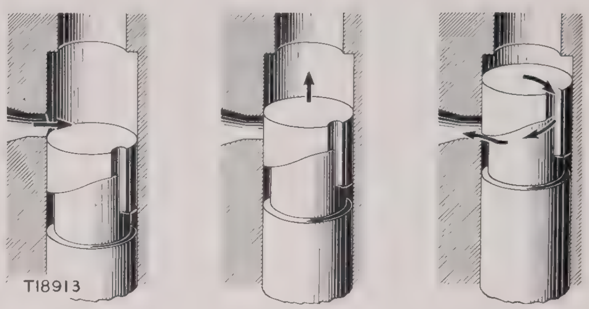


FIG. A
Port Uncovered
Fuel Enters Barrel

FIG. B
Port Covered
Injection Begins

FIG. C
Port Uncovered
Injection Ends

Figures A, B and C illustrate the functioning of an injection pump as the plunger makes a stroke.

In Fig. A the plunger is down and the inlet port **(2)** is uncovered. Fuel flows into the space above the plunger through the slot and into the recess around the plunger.

In Fig. B the plunger has started up and the port is covered. The fuel is trapped and will be forced through the check valve, fuel line and injection valve as the plunger moves upward.

In Fig. C the plunger has risen until the port is uncovered by the recess in the plunger. The fuel can now escape back through the port into the fuel manifold and injection will cease.

It will be noted that the recess in the pump plunger forms a helix around the upper end of the plunger. Figures D, E and F illustrate how rotating the pump plunger affects the quantity of fuel injected.

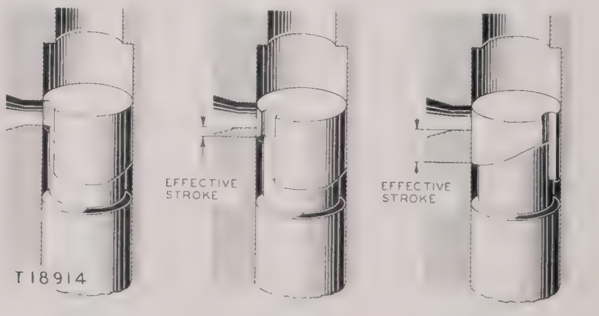


FIG. D
SHUT-OFF

FIG. E
IDLING POSITION

FIG. F
FULL LOAD POSITION

In Fig. D the plunger has been rotated into the shut-off position. The slot connecting the top of the plunger with the recess is in line with the port; therefore, no fuel can be trapped and injected.

In Fig. E the plunger has been rotated into the idling position. The narrow part of the plunger formed by the helix will cover the port for only a short part of the stroke. This permits only a small amount of the fuel to be injected per stroke.

In Fig. F the plunger has been rotated into the full load position. The wide part of the plunger formed by the helix covers the port for a longer part of the stroke. This permits a larger amount of fuel to be injected per stroke.

Worn fuel injection pumps will result in loss of power and hard starting. These same conditions may be present if the piston rings and cylinder liners are badly worn. However, in the case of worn piston rings and liners, the hard starting and loss of power will be accompanied by poor compression, a smoky exhaust and excessive blow-by gases from the crankcase breather.

Ordinarily, if one fuel injection pump on an engine is worn, it will be found that all of the injection pumps are worn and need replacing.

Failure to replace all of the worn injection pumps may result in erratic and irregular engine operation.

FUEL INJECTION PUMP HOUSING

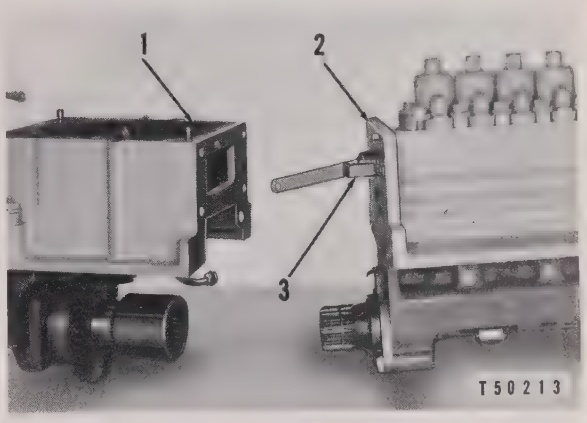
Removal and Installation

1. Remove the fuel pump and governor drive housing from the engine. See the topic, FUEL PUMP AND GOVERNOR DRIVE REMOVAL.
2. Remove the governor. See the covering topic.
3. Remove the bolts which hold the fuel injection pump housing **(2)** to the fuel pump and governor drive housing **(1)**.

CAUTION

Before removing the fuel injection pump housing from the fuel pump and governor drive housing, check to see if there is a rack stop **(3)** installed on the fuel injection pump housing. If there is no rack stop or if the rack stop is the type which bolts to the governor drive pinion cage assembly, then extreme care should be taken when removing the fuel injection pump housing. If proper care is not taken, it is possible that the rack can be pulled too far out of the housing, thus allowing the rack to become disengaged from the fuel pump gear segments. Should this occur, then each injection pump must be checked for proper engagement upon installation of the injection pump housing.

4. Move the fuel injection pump housing away from the governor drive housing.
5. Install in the reverse order of removal, replacing any damaged seals or gaskets.



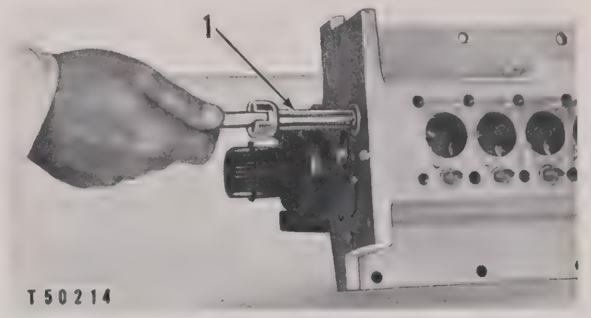
FUEL INJECTION PUMP HOUSING REMOVAL
1–Fuel pump and governor drive housing. 2–Fuel injection pump housing. 3–Rack stop.

NOTE

It is necessary to time the fuel injection pump camshaft to the engine crankshaft whenever the fuel injection pump housing or fuel injection pump and governor drive housing has been removed. See the topic, TIMING THE FUEL INJECTION PUMP CAMSHAFT.

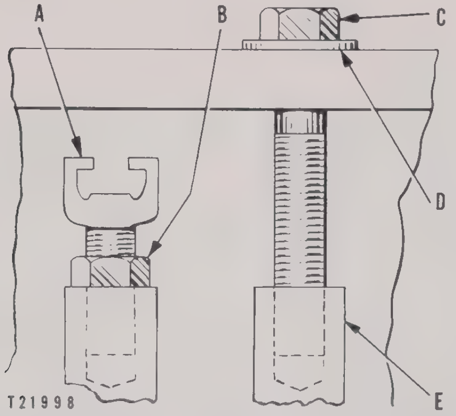
Disassembly and Assembly

1. Remove all the fuel injection pumps.
2. Remove the fuel rack stop, which limits the travel of the fuel rack, and remove the rack assembly **(1)**. The rack should fit freely in its bearings.



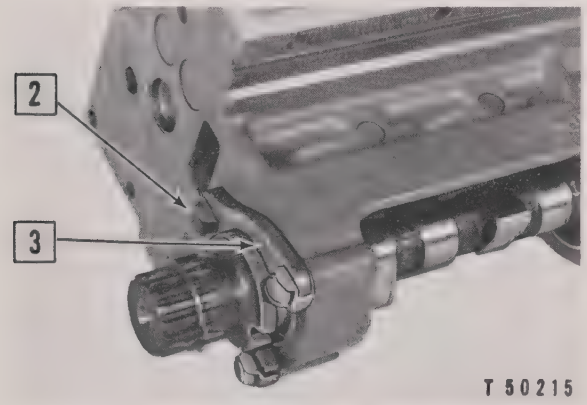
FUEL RACK REMOVAL
1–Fuel rack.

3. Loosen the locknuts **(B)** and remove the lifter yokes **(A)**.
4. Install the bolts **(C)** through the washers **(D)** and into the threaded end **(E)** of the lifters. The 6F7031 Bolts 3/8" - 24 (NF) 3" long and the 4F3714 Washers are suitable for this use



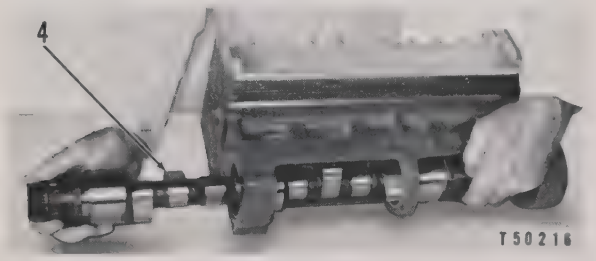
REMOVING LIFTER YOKES AND RAISING LIFTERS
A–Lifter yoke. B–Locknut. C–Bolt. D–Washer.
E–Threaded end of lifter.

5. Thread the bolts into the lifters far enough to raise the lifters free from the camshaft.



THRUST PLATE REMOVAL
☐ Remove
2–Bolts and locks. 3–Thrust plate.

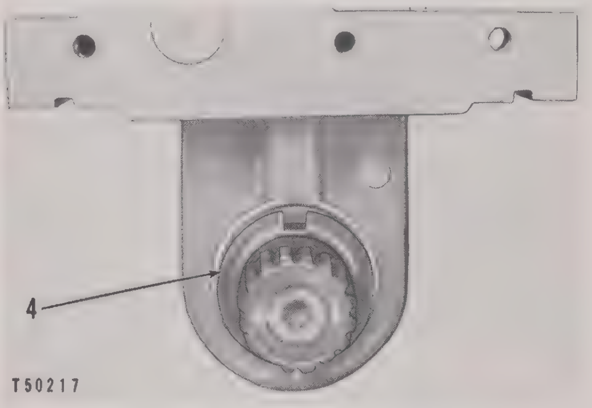
6. Remove the camshaft **(4)** as shown, taking care not to damage the camshaft bearings.



REMOVING CAMSHAFT
4–Camshaft.

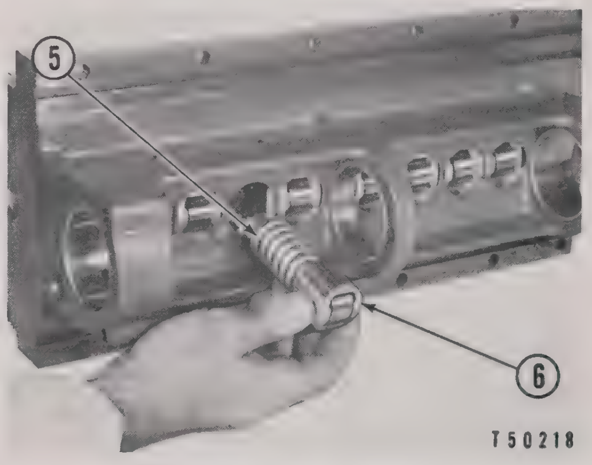
NOTE

Fuel injection pump camshafts have an arrow and an F-mark stamped on one end. For counterclockwise rotation engines, the camshaft is installed with the arrow and the F-mark at the front of the fuel injection pump housing as shown. For clockwise rotation of the engine, the camshaft is turned end for end and installed with the arrow and the F-mark at the rear of the fuel injection pump housing.



FUEL INJECTION CAMSHAFT MARKS
(Front View)
4–Camshaft.

7. Remove the bolt from the fuel pump lifter **(6)** and remove the lifter and spring **(5)** from the bottom of the housing as shown.

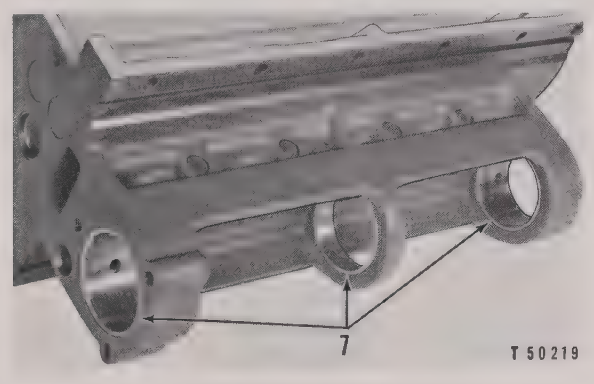


LIFTER AND SPRING REMOVAL
5–Spring. 6–Fuel pump lifter.

8. Inspect the camshaft bearings **(7)** and the fuel rack bearings for wear or damage and replace if necessary. When the clearance between the camshaft and bearings exceeds the permissible clearance given in the topic, SPECIFICATIONS, replacement of the bearings or camshaft, or both, is necessary to insure proper operation.

CAUTION

When removing and installing the camshaft bearings, distribute the pressure evenly around the edge of the bearings to prevent distortion or damage to the bearing surface. Bearing clearances are held to very close limits and a slight amount of distortion will cause the camshaft to bind in its bearings.



CAMSHAFT BEARINGS
7–Bearings.

NOTE

Be sure to align the oil hole in the bearing with the oil hole in the fuel injection pump housing.

9. Assemble in the reverse order of disassembly.
10. After installation of the fuel injection pump housing and timing of the pump camshaft, adjust the lifter settings. See the topic, FUEL PUMP LIFTER SETTING (ON ENGINE).

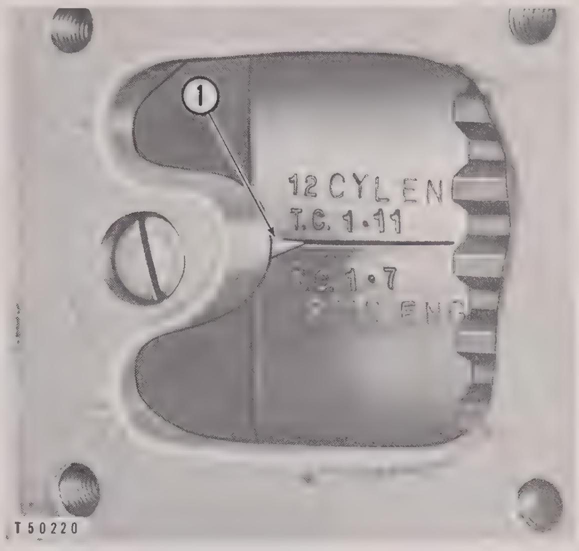
FUEL PUMP LIFTER SETTING (ON ENGINE)

If the injection pump lifters have been removed or disturbed from their original settings, it is necessary to reset them. If the lifter is too high, injection will begin early, and, if too low, injection will be late.

The lifter settings should also be checked periodically, and reset if necessary, to account for wear in the timing gears, pump lifters, and on the bottom of the plungers. See the topic, FUEL INJECTION PUMP LIFTER YOKE AND PUMP PLUNGER INSPECTION.

Injection pump lifters can be set more accurately with the fuel injection pump housing in place on the engine, since all timing gear wear can be compensated for by this method.

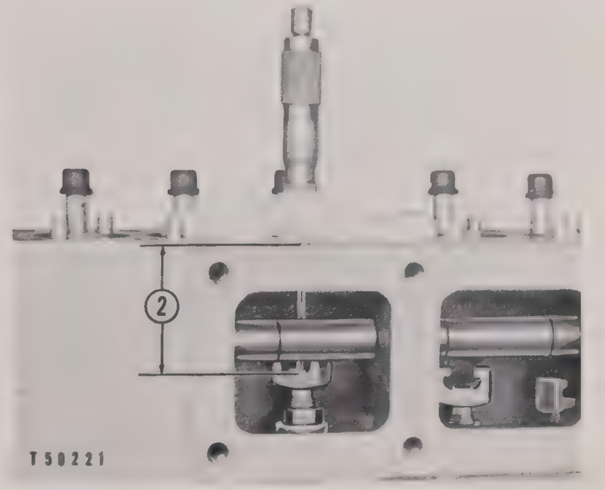
1. Remove the timing mark cover on the flywheel housing and the injection pump of the respective lifter to be set.
2. Turn the crankshaft in the direction of rotation until the pointer **(1)** aligns with the flywheel mark indicating piston top dead center on the compression stroke of the piston for which the corresponding lifter is to be set.



TIMING MARK ON FLYWHEEL
1–Pointer.

NOTE

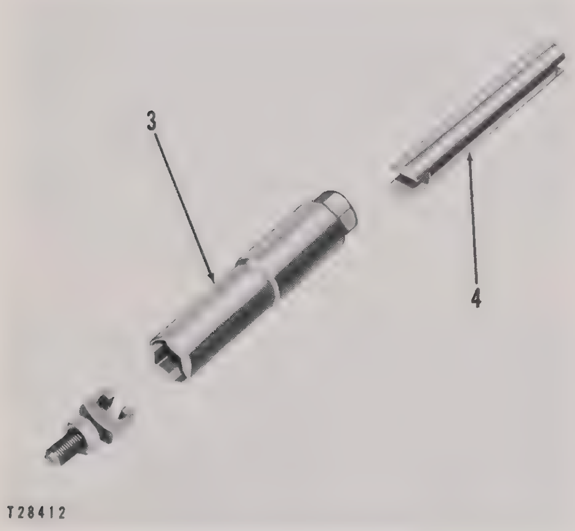
If the flywheel is turned too far, turn it back about 60° and again bring it up to the top dead center mark. This procedure eliminates error which might otherwise occur because of backlash in the timing gears. The fuel pumps are numbered consecutively from front to rear.



MEASURING LIFTER SETTING
2–Distance to be measured.

3. Check the pump lifter setting when at this position with the 6F6922 Micrometer Depth Gauge as shown.

4. Using lifter adjustment wrenches **(3)** and **(4)**, check and/or adjust the distance **(2)**. See the topic, SPECIFICATIONS, for correct lifter setting.
5. If all the lifters are to be checked or reset, continue the same procedure in the firing order of the engine. Recheck each lifter setting after the adjustment has been made and the locknut tightened to make sure the setting has not changed.



LIFTER SETTING WRENCHES
3–6H3051 Lifter Adjustment Wrench. 4–5H9977 Lifter Adjustment Wrench.

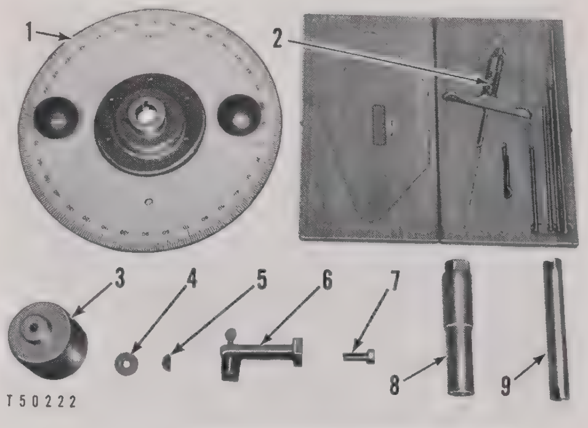
NOTE

The maximum quantity of fuel that can be injected by each pump into the cylinder, and accordingly, the maximum horsepower output of the engine at a given operating speed is determined by the fuel rack setting. This rack setting should be changed only in accordance with information furnished Caterpillar dealers. See the topic, GOVERNOR ADJUSTMENTS.

FUEL PUMP LIFTER SETTING (OFF ENGINE)

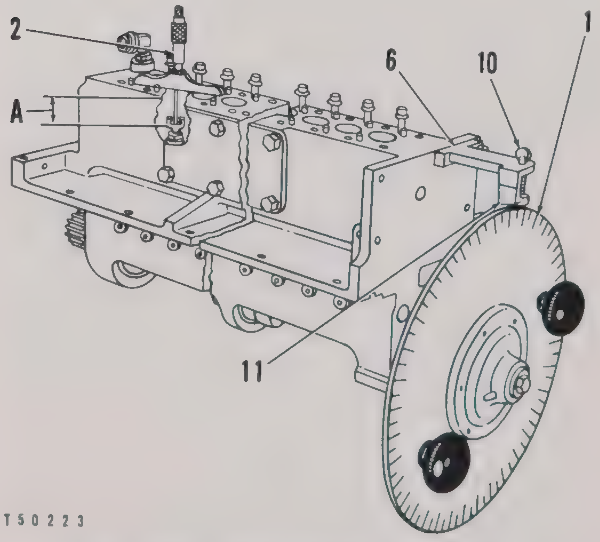
The following procedure for checking the lifters with the pump housing off the engine will result in correct fuel injection timing if the pump housing is installed on a new engine, or an engine with new timing gears. This method does not compensate for wear that may be present on timing gears and coupling in an engine that has seen considerable service. Therefore, to insure correct fuel injection timing, it is very important to recheck the lifter settings with the pump housing installed on the engine on which it is intended to remain. Follow the procedure described under the topic, FUEL PUMP LIFTER SETTING (ON ENGINE).

The tools shown are all the tools necessary for adjusting the lifters off the engine.



TOOLS REQUIRED FOR ADJUSTING LIFTERS OFF ENGINE
1–1F8747 Timing Plate. 2–6F6922 Micrometer Depth Gauge. 3–8M9018 Shaft. 4–3F1417 Washer. 5–No. 9 Woodruff Key. 6–8M9015 Adapter. 7–L1351 Bolt. 8–5H9977 Lifter Adjusting Wrench. 9–6H3051 Lifter Adjusting Wrench.

1. Attach the timing plate **(1)** to the rear of the camshaft using the shaft **(3)**, key **(5)**, bolt **(7)** and washer **(4)**. Align the key in the shaft **(3)** with the slot in the camshaft. This positions the timing plate properly in relation to the camshaft and allows the camshaft to be rotated by the timing plate.



FUEL PUMP LIFTER SETTING OFF ENGINE
1–1F8747 Timing Plate. 2–6F6922 Micrometer Depth Gauge. 6–8M9015 Adapter. 10–Lockscrew. 11–Edge of boss. A–Dimension to be measured.

2. Place the adapter **(6)** over the dowel in the end of the pump housing and bolt it in place.

3. Refer to the table in the topic, SPECIFICATIONS, and select the appropriate timing plate setting for the lifter being checked or set. Set the timing plate to this setting by rotating it clockwise for clockwise rotation engines or counterclockwise for counterclockwise rotation engines until the proper degree setting lines up with the inside edge of the boss **(11)** on the adapter assembly **(6)**. Lock in position with the lockscrew **(10)**.
4. Using the depth gauge **(2)**, check the fuel pump lifter setting (dimension A). This dimension is the distance from the flat surface on the top of the housing to the plunger seating surface on the yoke of the lifter being set. Adjust, if necessary, using the lifter adjusting wrenches **(8)** and **(9)**. See the topic, SPECIFICATIONS, for the correct fuel pump lifter setting.

NOTE

Be sure the flat surface on top of the fuel pump housing is clean, dry and free of paint. The depth gauge must be level to get an accurate reading.

5. If all the lifters are to be checked or reset, continue the same procedure in the firing order of the engine. Recheck each lifter setting after the adjustment has been made and the locknut tightened to make sure the setting has not changed.

FUEL PUMP LIFTER YOKE AND PUMP PLUNGER INSPECTION

Adjusting the fuel pump lifters is necessary whenever they have been removed from the housing. The adjustment should also be checked to compensate for wear in the lifter yokes to assure that the point of fuel injection is correct. If the lifter is too high, injection will begin early, and, if too low, injection will be late.

When pump plunger wear becomes excessive, the lifter yoke may also be worn in such a manner that it will not make full contact with the end of a new plunger. To avoid rapid wear on the end of the new plunger, lifter yokes showing visible wear should always be replaced.

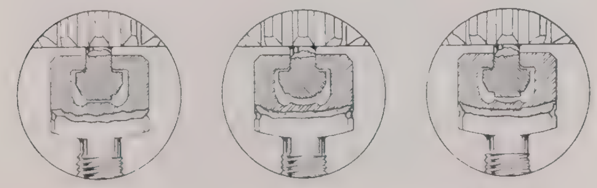
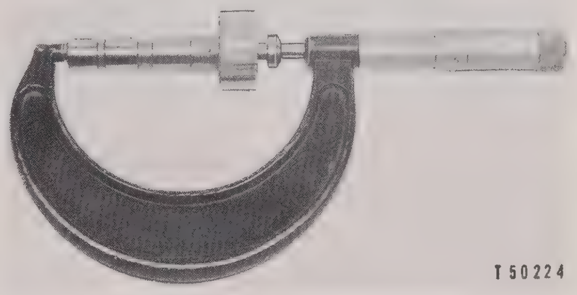


FIG. A T18925 FIG. B FIG. C

WEAR BETWEEN YOKE AND PLUNGER

Fig. A illustrates the contact surfaces of a new pump plunger and a new lifter yoke. In Fig. B, the pump plunger and lifter yoke have worn considerably. Fig. C shows how the flat end of a new plunger makes poor contact with a worn lifter yoke, resulting in rapid wear to both parts.

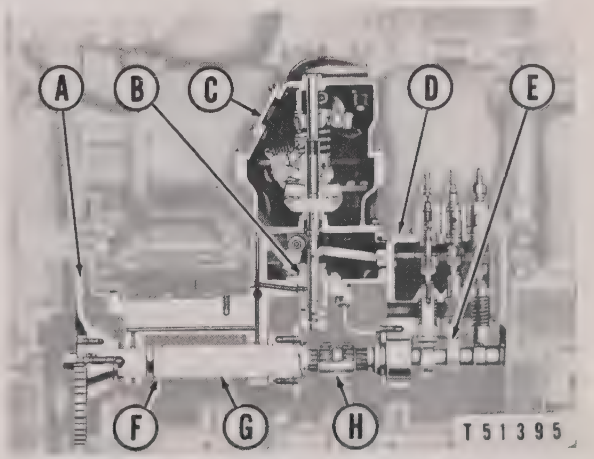
A pump can maintain a satisfactory discharge rate and yet be unserviceable because of delayed timing resulting from wear on the lower end of the plunger. When testing a pump which has been in use for a long time, the length of the plunger should be checked with a micrometer as shown. The length of new plungers and the maximum permissible wear of old plungers are given in the topic, SPECIFICATIONS.



CHECKING LENGTH OF PLUNGER

TIMING THE FUEL INJECTION PUMP CAMSHAFT

Introduction



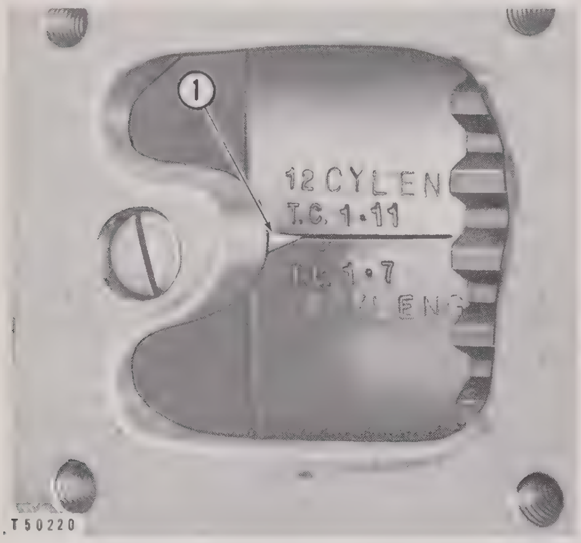
FUEL PUMP AND GOVERNOR DRIVE

A–Fuel pump and governor drive gear. B–Governor drive pinion cage assembly. C–Governor. D–Fuel injection pump housing. E–Fuel injection pump camshaft. F–Tachometer drive gear. G–Fuel pump and governor drive shaft. H–Coupling.

Timing

It is necessary to time the fuel injection pump camshaft to the engine crankshaft whenever the pump housing or injection pump drive has been removed.

The method described may also be used to check injection pump timing.

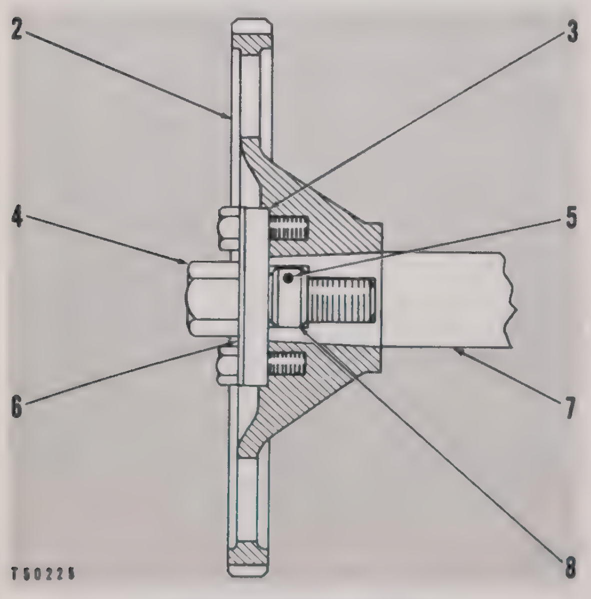


TIMING MARK ON FLYWHEEL
1–Pointer.

1. Remove the timing mark cover on the flywheel housing and turn the flywheel in the direction of rotation until No. 1 piston is at top dead center on compression as indicated by the flywheel pointer **(1)**.

NOTE

If the flywheel is turned too far, turn it back about 60° and again bring it up to the top dead center mark on the compression stroke.



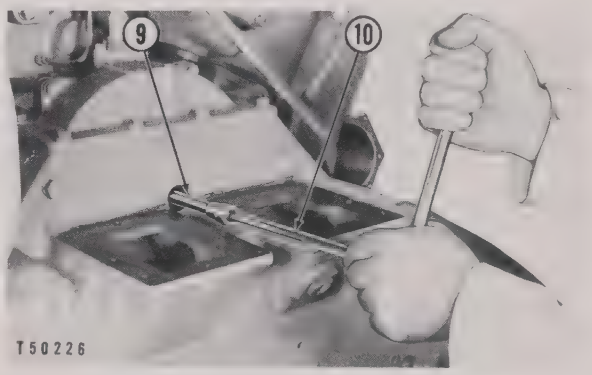
CAMSHAFT GEAR ASSEMBLY
2–Gear. 3–Plate. 4–Puller bolt. 5–Taper pin. 6–Lock. 7–Shaft. 8–Collar.

2. The fuel pump and governor drive gear **(2)** has a puller built in which is a part of the gear assembly. This puller is used to loosen the gear on the drive shaft.

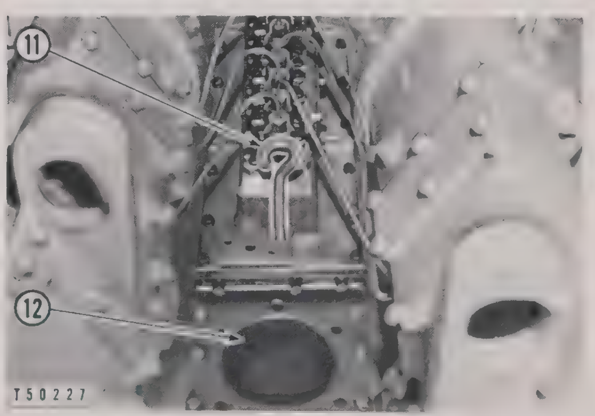
NOTE

The puller consists of a bolt **(4)**, plate **(3)**, collar **(8)** and taper pin **(5)**. The puller bolt is retained in the plate by a collar secured with the taper pin. The plate is bolted to the gear **(2)**. When the puller bolt is turned counterclockwise, the collar exerts pressure against the plate and pulls the gear from the shaft **(7)**. When the bolt is turned clockwise, the gear is forced on the tapered shaft by the plate.

3. Remove the plug from the top of the flywheel housing. Pull the governor and fuel pump drive camshaft gear from the shaft. A piece of ½″ hexagonal bar stock **(9)** 6″ long with an extension wrench **(10)** can be used to turn the puller bolt. The lock **(6)** can be spread with a screwdriver.

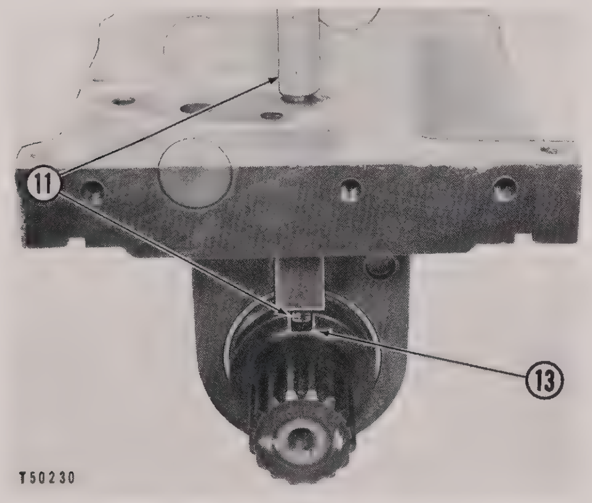


PULLING THE GOVERNOR AND FUEL PUMP DRIVE CAMSHAFT GEAR
(Aftercooler Removed For Better Illustration)
9–½″ hexagonal bar stock. 10–Extension.



TIMING THE FUEL INJECTION PUMP
11–Lifting eye. 12–Breather cavity.

4. Remove the fuel injection pump housing lifting eye **(11)** and the fuel inlet flange.
5. Remove the breather in front of the fuel injection pump housing.
6. Insert the lifting eye, which also serves as the timing pin, into the hole from which it was removed. Do not tighten at this time.
7. Reach through the breather cavity **(12)** and turn the fuel pump camshaft until the timing slot **(13)** is on top and screw the lifting eye into the timing slot as illustrated.



TIMING PIN LOCATED IN TIMING SLOT
(Pump Housing Removed for Clearer Illustration)
11–Lifting eye. 13–Timing slot.

NOTE

The F-mark and arrow on the end of the camshaft indicate direction of rotation only. For counterclockwise rotation engines, the camshaft is installed with the arrow and F-mark at the front of the fuel injection pump housing as shown. For clockwise rotation engines, the camshaft is turned end for end and installed with the arrow and F-mark at the rear of the fuel injection pump housing.

8. With the lifting eye in place, tighten the puller bolt which forces the gear onto the shaft. Bend the lock **(7)** into place on the bolt.
9. Remove the lifting eye. The fuel injection pump camshaft is in time.

Fuel Injection Equipment

The most likely causes for faulty fuel injection performance are:

1. Air in the fuel system.
2. Low fuel supply.
3. Water in the fuel.
4. Clogged fuel filters.
5. Insufficient fuel transfer pump pressure.

If these conditions are checked and corrected and the engine still does not perform properly, the fuel injection equipment should be checked.

CHECKING FUEL INJECTION EQUIPMENT

Before removing a fuel injection pump or valve for testing from an engine that is missing or puffing black smoke at the exhaust, a simple check can be made to determine which cylinder is causing the difficulty. With the engine running at a speed which makes the defect most pronounced, momentarily loosen the fuel line nut on the injection pump sufficiently to cut out the cylinder. Check each cylinder in the same manner. If one is found where loosening makes no difference in the irregular operation of the engine or causes puffing of black smoke at exhaust to cease, probably the pump and valve, for only that cylinder, need be tested.

FUEL INJECTION VALVE

The function of the fuel injection valves is to inject and atomize the fuel from the fuel injection pumps into the precombustion chambers. Irregular engine operation and smoking may be caused by an improperly operating injection valve.

The fuel injection valve is installed in the precombustion chamber.

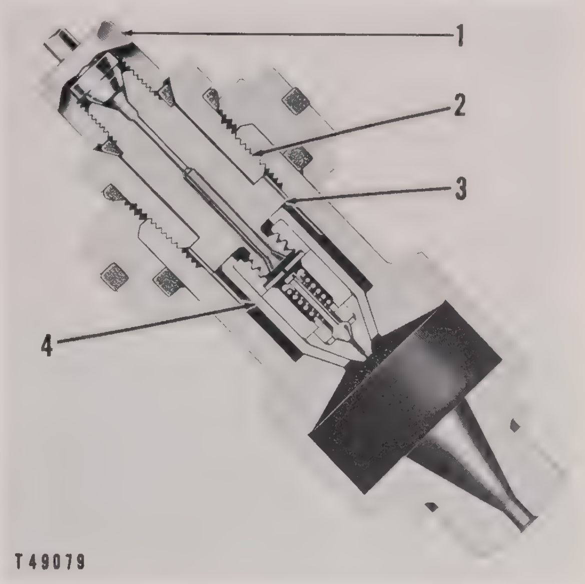
The fuel injection valve assembly consists of the body **(3)**, nut **(2)**, and the capsule-type nozzle assembly **(4)**.

Only the nozzle assembly need be replaced.

The nozzle assembly **(4)** and body **(3)** are held in place by the nut **(2)**, and they can be removed by disconnecting the fuel line assembly **(1)** and removing the nut and seal.

The body and the nozzle assembly can then be lifted out. The nozzle assembly is only finger-tight on the body.

When installing a fuel injection valve, always check the seats of both the nozzle and the precombustion chamber.



FUEL INJECTION VALVE CROSS-SECTION
1–Fuel line assembly. 2–Nut. 3–Body. 4–Nozzle assembly.

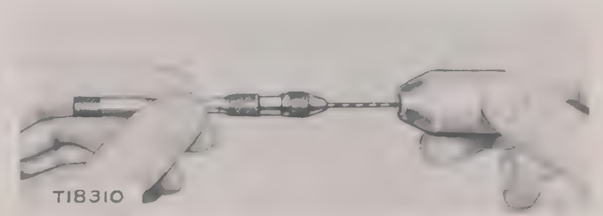
Tighten the nut **(2)** to the torque value given in the topic, SPECIFICATIONS. Excessive tightness will damage the nozzle. Excessive looseness will allow the nozzle to leak and in some instances cause the nozzle case to bulge or split.

Cleaning Fuel Injection Valve

The operation of the engine will be affected if the orifice in the nozzle becomes partially filled with carbon. To correct this, remove the nozzle assembly from the valve body and clean the fuel discharge hole using the drill listed in the topic, SPECIFICATIONS, and a 5B1254 Chuck which are part of the 5B1401 Cleaning Tool Group. If after cleaning, the valve does not operate properly, the nozzle should be checked for leakage.

CAUTION

Do not attempt to clean the carbon from the end of the injection nozzle with a wire brush or wheel. The only maintenance required on the injection nozzle is to clean the fuel discharge hole using the correct size drill as indicated



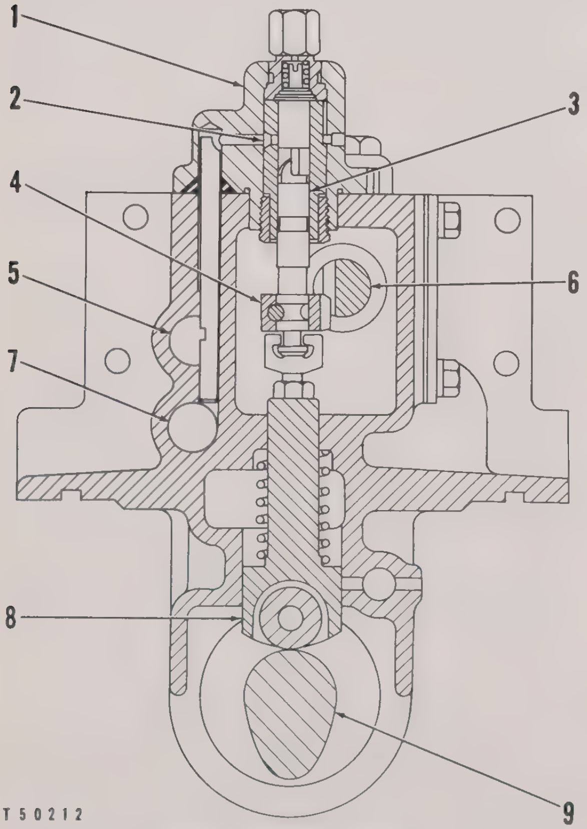
CLEANING FUEL INJECTION NOZZLE ASSEMBLY

Checking Fuel Injection Valve

The condition of a capsule type nozzle assembly can be tested out of the engine on the Caterpillar Diesel Fuel Injection Test Apparatus. The spray characteristic, valve unseating pressure, and the rate of leakage of the nozzle assembly can be determined.

FUEL INJECTION PUMPS

Air in the fuel system is bled through the bleeder manifold **(5)** when the bleeder valve is opened and fuel enters the bleeder manifold through passage **(7)**. The injection pump plungers **(3)** and the lifters **(8)** are lifted by cams on the camshaft **(9)** and always make a full stroke. Each pump **(1)** measures the amount of fuel to be injected into its respective cylinder and delivers it to the fuel injection valve.



FUEL INJECTION PUMP
1–Pump. 2–Inlet port. 3–Pump plunger. 4–Gear segment. 5–Bleeder manifold. 6–Rack. 7–Fuel passage. 8–Lifter. 9–Camshaft.

The amount of fuel pumped per stroke can be varied by turning the plunger in the barrel. The plunger is turned by the governor action through the rack **(6)** which meshes with the gear segment **(4)** on the bottom of the pump plunger.

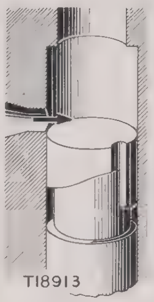


FIG. A
Port Uncovered Fuel Enters Barrel

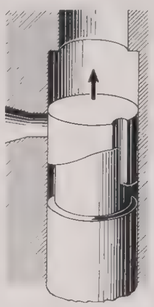


FIG. B
Port Covered Injection Begins

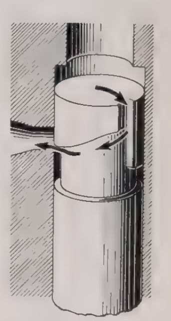


FIG. C
Port Uncovered Injection Ends

Figures A, B and C illustrate the functioning of an injection pump as the plunger makes a stroke.

In Fig. A the plunger is down and the inlet port **(2)** is uncovered. Fuel flows into the space above the plunger through the slot and into the recess around the plunger.

In Fig. B the plunger has started up and the port is covered. The fuel is trapped and will be forced through the check valve, fuel line and injection valve as the plunger moves upward.

In Fig. C the plunger has risen until the port is uncovered by the recess in the plunger. The fuel can now escape back through the port into the fuel manifold and injection will cease.

It will be noted that the recess in the pump plunger forms a helix around the upper end of the plunger. Figures D, E and F illustrate how rotating the pump plunger affects the quantity of fuel injected.

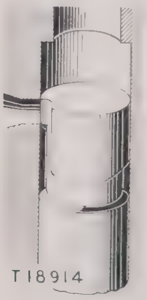


FIG. D
SHUT-OFF

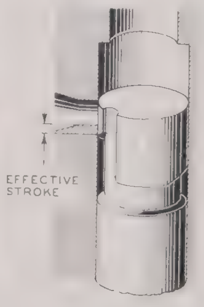


FIG. E
IDLING POSITION

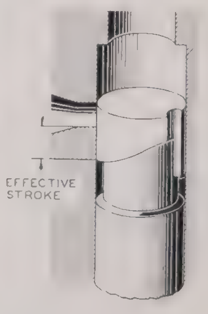


FIG. F
FULL LOAD POSITION

In Fig. D the plunger has been rotated into the shut-off position. The slot connecting the top of the plunger with the recess is in line with the port; therefore, no fuel can be trapped and injected.

In Fig. E the plunger has been rotated into the idling position. The narrow part of the plunger formed by the helix will cover the port for only a short part of the stroke. This permits only a small amount of the fuel to be injected per stroke.

In Fig. F the plunger has been rotated into the full load position. The wide part of the plunger formed by the helix covers the port for a longer part of the stroke. This permits a larger amount of fuel to be injected per stroke.

Worn fuel injection pumps will result in loss of power and hard starting. These same conditions may be present if the piston rings and cylinder liners are badly worn. However, in the case of worn piston rings and liners, the hard starting and loss of power will be accompanied by poor compression, a smoky exhaust and excessive blow-by gasses from the crankcase breather.

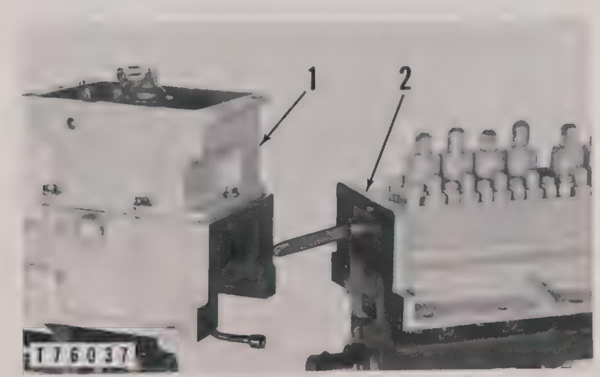
Ordinarily, if one fuel injection pump on an engine is worn, it will be found that all of the injection pumps are worn and need replacing.

Failure to replace all of the worn injection pumps may result in erratic and irregular engine operation.

FUEL INJECTION PUMP HOUSING

Removal and Installation

1. Remove the fuel pump and governor drive housing from the engine. See the topic, FUEL PUMP AND GOVERNOR DRIVE REMOVAL.
2. Remove the governor. See the covering topic.
3. Remove the bolts which hold fuel injection pump housing **(2)** to fuel pump and governor drive housing **(1)** and separate the housings.
4. Install in the reverse order of removal, replacing any damaged seals or gaskets.



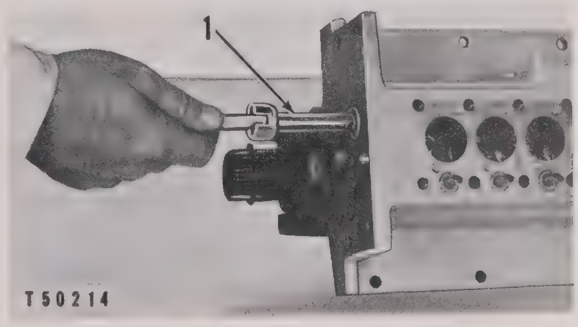
FUEL INJECTION PUMP HOUSING REMOVAL
1–Fuel pump and governor drive housing. 2–Fuel injection pump housing.

NOTE

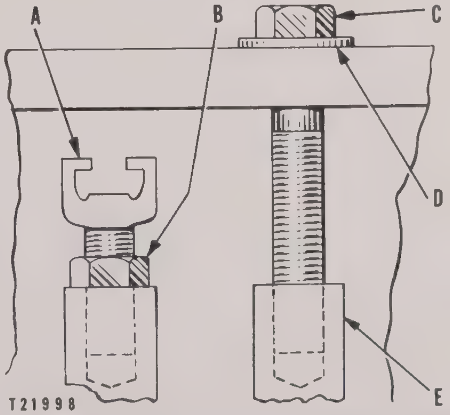
It is necessary to time the fuel injection pump camshaft to the engine crankshaft when either the fuel injection pump housing or the fuel injection pump and governor drive housing has been removed. See the topic TIMING THE FUEL INJECTION PUMP CAMSHAFT.

Disassembly and Assembly

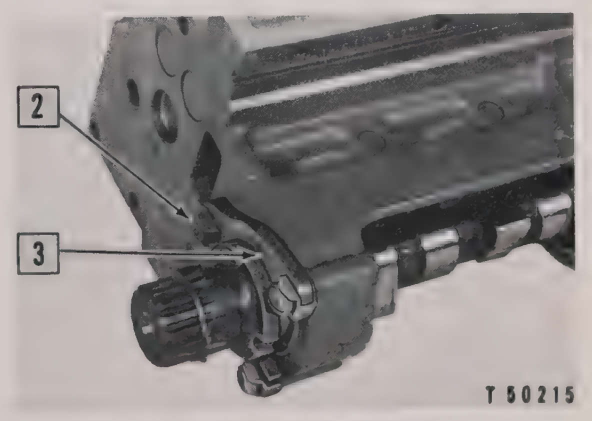
1. Remove all the fuel injection pumps.
2. Remove fuel rack **(1)**. The rack must slide freely in its bearings.



FUEL RACK REMOVAL
1–Fuel rack.

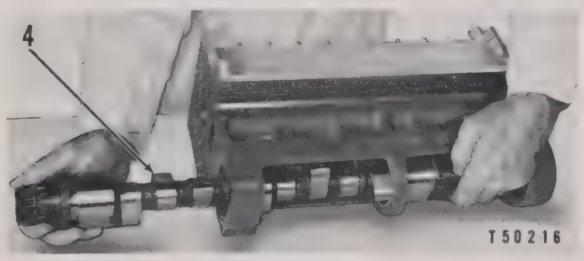


REMOVING LIFTER YOKES AND RAISING LIFTERS
A–Lifter yoke. B–Locknut. C–Bolt. D–Washer. E–Threaded end of lifter.



THRUST PLATE REMOVAL
2–Bolts and locks. 3–Thrust plate.

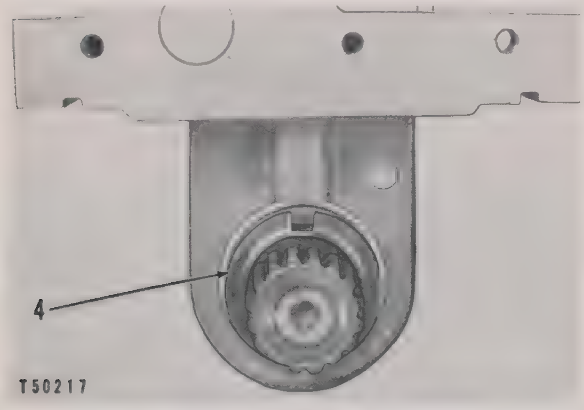
3. Loosen the locknuts **(B)** and remove the lifter yokes **(A)**.
4. Install bolts **(C)** through washers **(D)** and into threaded ends **(E)** of the lifters. Use 6F7031 Bolts ($\frac{3}{8}$″ - 24 NF thread, 3″ long) and 4F3714 Washers.
5. Screw the bolts into the lifters far enough to raise the lifters free from the camshaft.
6. Remove camshaft **(4)**, taking care not to damage the camshaft bearings.



REMOVING CAMSHAFT
4–Camshaft.

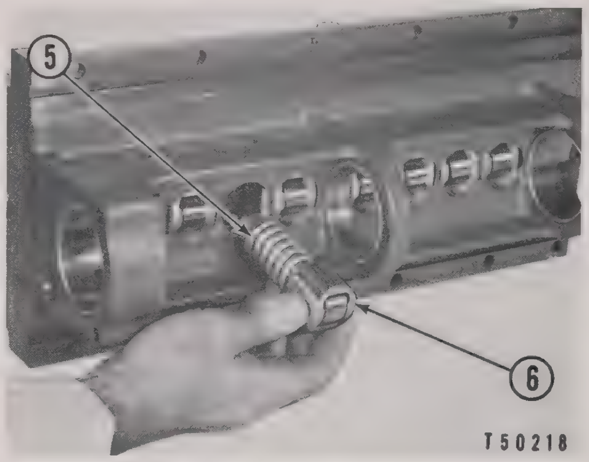
NOTE

Fuel injection pump camshafts have an arrow and an F-mark stamped on one end. For counterclockwise rotation engines, the camshaft is installed with the arrow and the F-mark at the front of the fuel injection pump housing as shown. For clockwise rotation of the engine, the camshaft is turned end for end and installed with the arrow and the F-mark at the rear of the fuel injection pump housing.



FUEL INJECTION CAMSHAFT MARKS
(Front View)
4–Camshaft.

7. Remove the bolt from fuel pump lifter **(6)** and remove the lifter and spring **(5)** from the bottom of the housing.

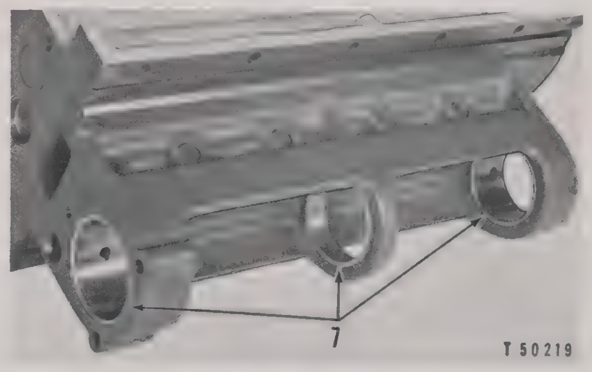


LIFTER AND SPRING REMOVAL
5–Spring. 6–Fuel pump lifter.

8. Inspect camshaft bearings **(7)** and the fuel rack bearings and replace if necessary. When the clearance between the camshaft and bearings exceeds the permissible clearance given in the SPECIFICATIONS, replacement of the bearings or camshaft, or both, is necessary to insure proper operation.

CAUTION

When removing or installing camshaft bearings, distribute the pressure evenly around the edge of the bearings to prevent distortion or damage to the bearing surface. Bearing clearances are held to very close limits and a slight amount of distortion will cause the camshaft to bind.



CAMSHAFT BEARINGS
7–Bearings.

NOTE

Be sure to align the hole in the bearing with the oil hole in the fuel injection pump housing.

9. Assemble in the reverse order of disassembly.
10. After installation of the fuel injection pump housing and timing of the pump camshaft, ad-

just the lifter settings. See the topic, FUEL PUMP LIFTER SETTING (ON ENGINE)

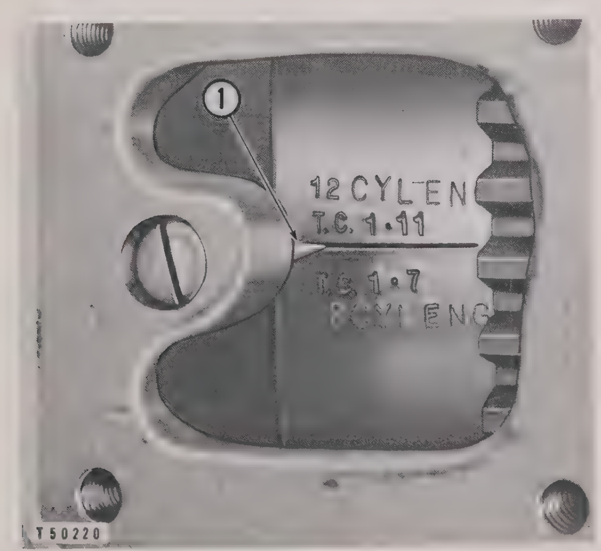
FUEL PUMP LIFTER SETTING (ON ENGINE)

If the injection pump lifters have been removed or disturbed from their original settings, it is necessary to reset them. If the lifter is too high, injection will begin early, and, if too low, injection will be late.

Setting the lifters will compensate for wear in the timing gears, pump lifters, and on the bottom of the plungers. See the topic FUEL INJECTION PUMP LIFTER YOKE AND PUMP PLUNGER INSPECTION.

Injection pump lifters can be set more accurately with the fuel injection pump housing in place on the engine, since all timing gear wear is compensated for by this method.

1. Remove the timing mark cover on the flywheel housing and the injection pump of the respective lifter to be set.
2. Turn the crankshaft in the direction of engine rotation until pointer **(1)** aligns with the flywheel mark indicating piston TC (top center) on the compression stroke of the piston for which the corresponding lifter is to be set.

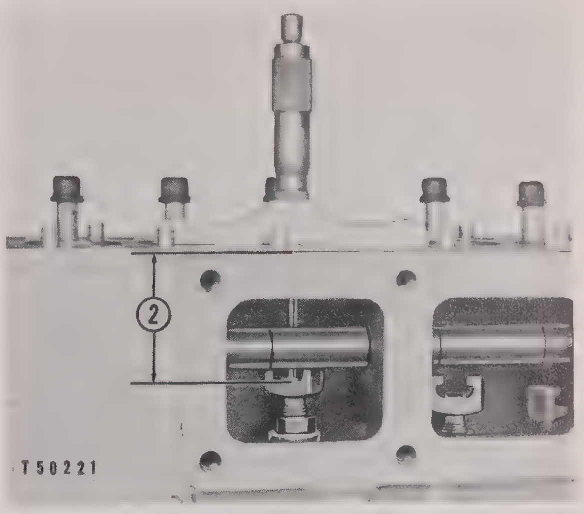


TIMING MARKS ON FLYWHEEL
1–Pointer.

NOTE

If the flywheel is turned too far, turn it back about 60° and again bring it up to the TC (top center) mark. This procedure eliminates error which might otherwise occur because of backlash in the timing gears. The fuel pumps are numbered consecutively from front to rear.

3. Check the pump lifter setting when at this position with the 6F6922 Micrometer Depth Gauge.



MEASURING LIFTER SETTING
2–Distance to be measured.

4. Use lifter adjustment wrenches **(3)** and **(4)**, to adjust distance **(2)**. See the SPECIFICATIONS for correct lifter setting.
5. If all the lifters are to be checked or reset, continue the same procedure in the firing order of the engine. Recheck each lifter setting after the adjustment has been made and the locknut tightened to make sure the setting has not changed.

LIFTER SETTING WRENCHES
3–6H3051 Lifter Adjustment Wrench. 4–5H9977 Lifter Adjustment Wrench.

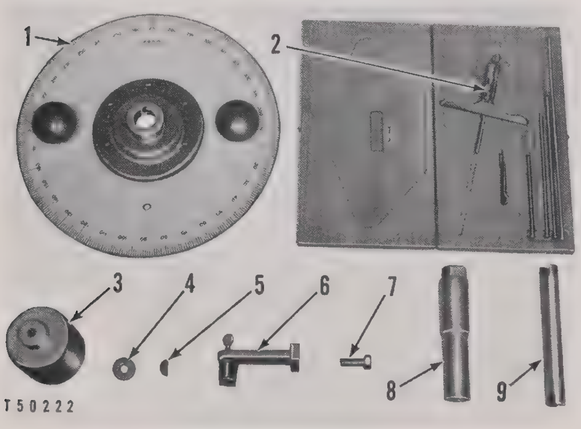
NOTE

See the topic GOVERNOR ADJUSTMENTS for setting the fuel rack.

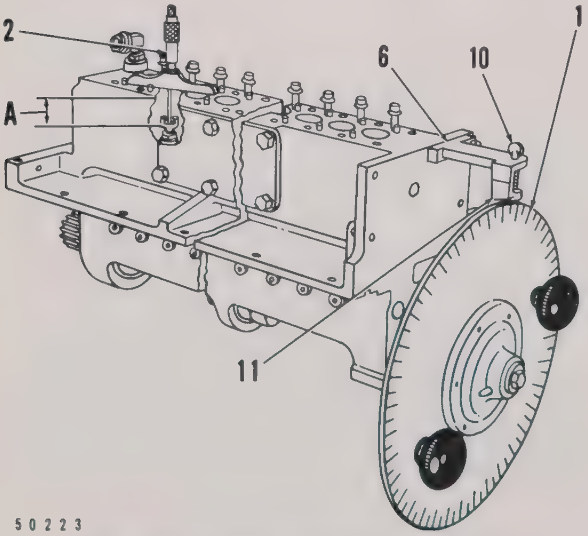
FUEL PUMP LIFTER SETTING (OFF ENGINE)

The following procedure for checking the lifters with the pump housing off the engine is for a new engine or an engine with new timing gears. If the method is used for setting the lifters on an engine with considerable service, it is very important to recheck the lifter settings after the pump housing is installed on the engine. See the topic FUEL PUMP LIFTER SETTING (ON ENGINE).

The tools shown are all the tools necessary for adjusting the lifters off the engine.



TOOLS REQUIRED FOR ADJUSTING LIFTERS OFF ENGINE
1-1F8747 Timing Plate. 2-6F6922 Micrometer Depth Gauge. 3-8M9018 Shaft. 4-3F1417 Washer. 5-No. 9 Woodruff Key. 6-8M9015 Adapter. 7-L1351 Bolt. 8-5H9977 Lifter Adjusting Wrench. 9-6H3051 Lifter Adjusting Wrench.



FUEL PUMP LIFTER SETTING OFF ENGINE
1-1F8747 Timing Plate. 2-6F6922 Micrometer Depth Gauge. 6-8M9015 Adapter. 10-Lockscrew. 11-Edge of boss. A-Dimension to be measured.

1. Attach timing plate **(1)** to the rear of the camshaft using shaft **(3)**, key **(5)**, bolt **(7)** and washer **(4)**. Align the key in shaft **(3)** with the slot in the camshaft. This positions the timing plate in relation to the camshaft and allows the camshaft to be rotated by the timing plate.
2. Place adapter **(6)** over the dowel in the end of the pump housing and bolt it in place.
3. Refer to the table in the SPECIFICATIONS and select the appropriate timing plate setting for the lifter being checked or set. Set the timing plate to this setting by rotating it clockwise for clockwise rotation engines or counterclockwise for counterclockwise rotation engines until the proper degree setting lines up with the inside edge of boss **(11)** on adapter assembly **(6)**. Lock in position with lockscrew **(10)**.
4. Use depth gauge **(2)** to check the fuel pump lifter setting (dimension A). This dimension is the distance from the flat surface on the top of the housing to the plunger seating surface in the yoke of the lifter being set. Adjust, if necessary, using lifter adjusting wrenches **(8)** and **(9)**. See the SPECIFICATIONS for the fuel pump lifter setting.

NOTE

To get an accurate depth gauge reading, be sure the flat surface on top of the fuel pump housing is clean, dry and free of paint.

5. If all the lifters are to be checked or reset, continue the same procedure in the firing order of the engine. Recheck each lifter setting after the adjustment has been made and the locknut tightened to make sure the setting has not changed.

FUEL PUMP LIFTER YOKE AND PUMP PLUNGER INSPECTION

Adjusting the fuel pump lifters is necessary whenever they have been removed from the housing. The adjustment should also be checked to compensate for wear in the lifter yokes to assure that the point of fuel injection is correct. If the lifter is too high, injection will begin early, and, if too low, injection will be late.

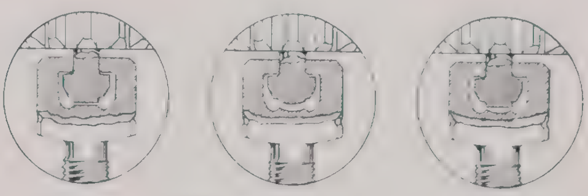


FIG. A T18925 FIG. B FIG. C

WEAR BETWEEN YOKE AND PLUNGER

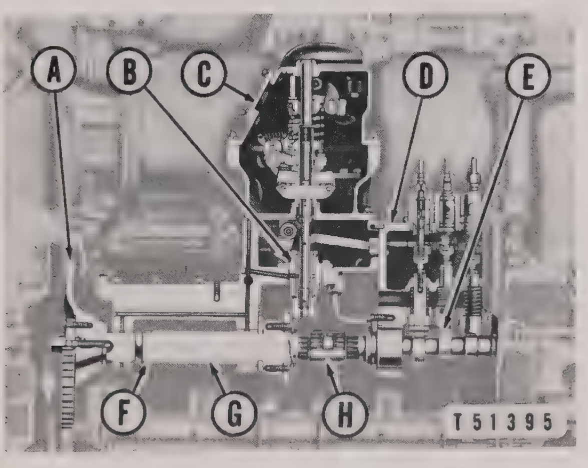
When pump plunger wear becomes excessive, the lifter yoke may also be worn in such a manner that it will not make full contact with the end of a new plunger. To avoid rapid wear on the end of the new plunger, lifter yokes showing visible wear should always be replaced.

Fig. A illustrates the contact surfaces of a new pump plunger and a new lifter yoke. In Fig. B, the pump plunger and lifter yoke have worn considerably. Fig. C shows how the flat end of a new plunger makes poor contact with a worn lifter yoke, resulting in rapid wear to both parts.

A pump can maintain a satisfactory discharge rate and yet be unserviceable because of delayed timing resulting from wear on the lower end of the plunger. When testing a pump which has been in use for a long time, the length of the plunger should be checked with a micrometer. The length of new plungers and the maximum permissible wear of old plungers are given in the SPECIFICATIONS.

TIMING THE FUEL INJECTION PUMP CAMSHAFT

Introduction



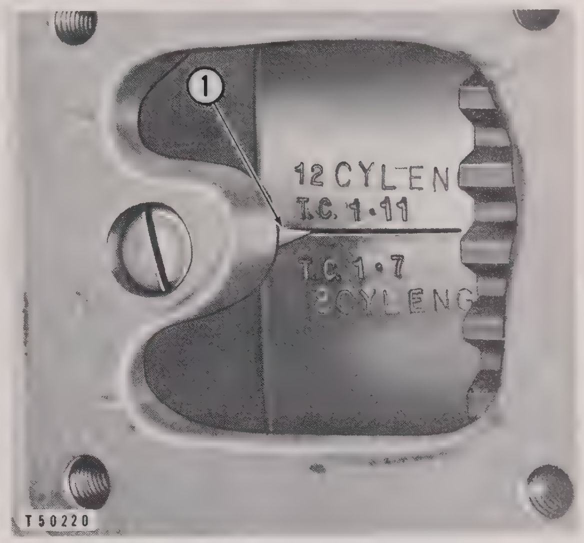
FUEL PUMP AND GOVERNOR DRIVE
A–Fuel pump and governor drive gear. B–Governor drive pinion cage assembly. C–Governor. D–Fuel injection pump housing. E–Fuel injection pump camshaft. F–Tachometer drive gear. G–Fuel pump and governor drive shaft. H–Coupling.

Timing

It is necessary to time the fuel injection pump camshaft to the engine crankshaft whenever the pump housing or injection pump drive has been removed.

The method described may also be used to check injection pump timing.

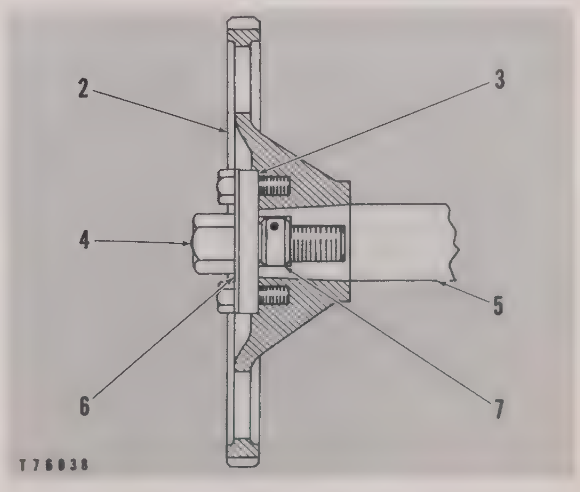
1. Remove the timing mark cover on the flywheel housing and turn the flywheel in the direction of engine rotation until No. 1 piston is at TC (top center) on compression as indicated by flywheel pointer **(1)**.



TIMING MARK ON FLYWHEEL
1–Pointer.

NOTE

If the flywheel is turned too far, turn it back about 60° and again rotate the flywheel in the direction of normal rotation until No. 1 piston is at TC (top center) on compression as indicated by the flywheel pointer.



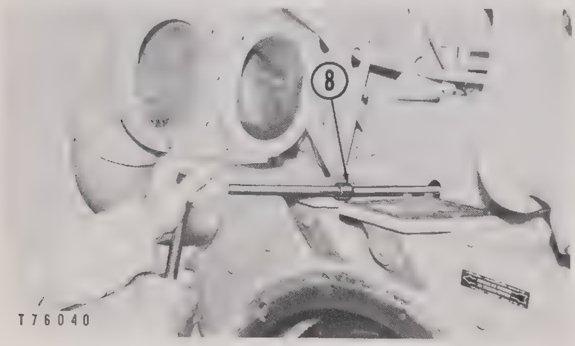
CAMSHAFT GEAR ASSEMBLY
2–Gear. 3–Plate. 4–Puller bolt. 5–Shaft. 6–Lock. 7–Collar.

2. The fuel pump and governor drive gear **(2)** has a built-in puller which is a part of the gear assembly. This puller is used to loosen the gear from the drive shaft

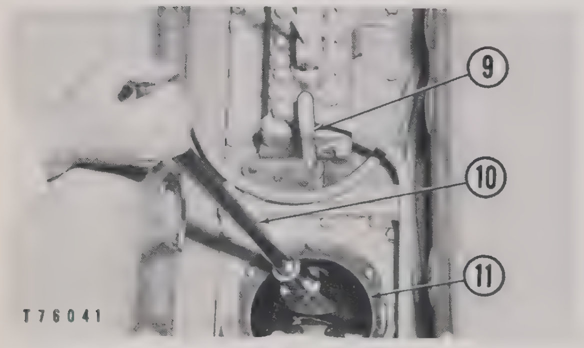
NOTE

The puller consists of bolt **(4)** and plate **(3)**. The puller bolt is retained in the plate by collar **(7)** welded to the bolt. The plate is bolted to gear **(2)**. When the puller bolt is turned counterclockwise, the force of collar **(7)** against the plate pulls the gear from shaft **(5)**. When the bolt is turned clockwise, the gear is forced on the tapered shaft by the plate.

3. Remove the plug from the top of the flywheel housing. Pull the governor and fuel pump drive camshaft gear from the shaft. Two ½″ drive wrench extensions **(8)** can be used to turn the puller bolt. Lock **(6)** can be spread with a screwdriver.



PULLING THE GOVERNOR AND FUEL PUMP DRIVE CAMSHAFT GEAR
(Aftercooler Removed For Better Illustration)
8–Wrench extensions.

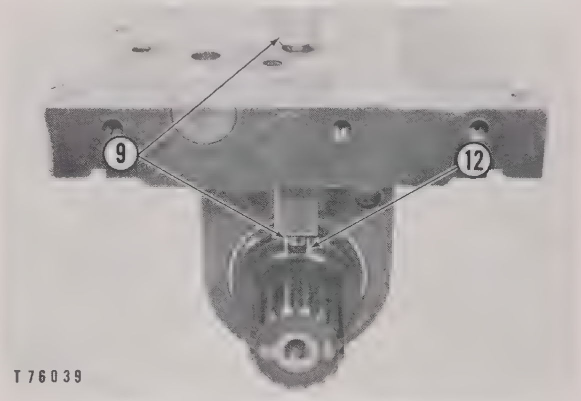


TIMING THE FUEL INJECTION PUMP
9–Lifting eye. 10–Ratchet wrench handle. 11–Breather cavity.

4. Remove lifting eye **(9)** and the fuel inlet flange.
5. Remove the breather in front of the fuel injection pump housing.
6. Insert the lifting eye (which is also a timing pin) into the hole from which it was removed. Do not tighten at this time.
7. Through breather cavity **(11)**, rotate the fuel pump camshaft until timing slot **(12)** is on top. Screw the lifting eye into the timing slot as illustrated.

NOTE

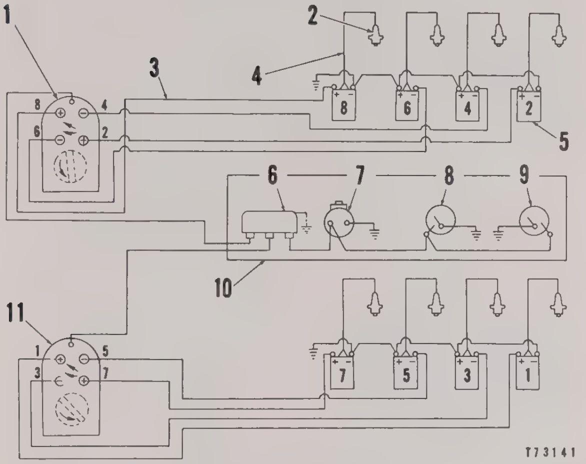
A fuel pump camshaft rotating tool can be fabricated by welding a socket wrench to one end of a camshaft-driveshaft coupling. Ratchet wrench handle **(10)** can now be used with the rotating tool to rotate the fuel pump camshaft accurately.



TIMING PIN LOCATED IN TIMING SLOT
(Pump Housing Removed for Clearer Illustration)
9–Lifting eye. 12–Timing slot.

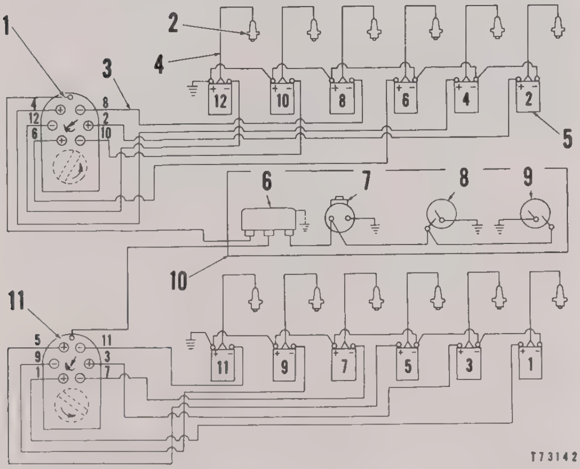
8. With the lifting eye in place, tighten the camshaft gear puller bolt and force the gear onto the shaft. Bend lock **(6)** into place on the bolt.
9. Remove the lifting eye. The fuel injection pump camshaft is in time.

INTRODUCTION



G379 IGNITION SYSTEM

1–Left bank magneto. 2–Spark plugs. 3–Low tension leads. 4–High tension leads. 5–Transformers. 6–Magnetic switch. 7–Manual stop switch. 8–Oil pressure gauge. 9–Water temperature gauge. 10–Instrument panel. 11–Right bank magneto.



G398 IGNITION SYSTEM
(Nomenclature same as previous illustration)

The ignition system consists of low tension magnetos **(1)** and **(11)**, ignition transformers **(5)**, low and high tension leads **(3)** and **(4)**, spark plugs **(2)** and a magnetic shutoff switch **(6)**.

Magnetos **(1)** and **(11)** generate primary voltage and deliver it through low tension leads **(3)** to ignition transformers **(5)**. The transformers boost the voltage induced by the magnetos and deliver this electrical surge through high tension leads **(4)** to spark plugs **(2)**. The spark ignites air/fuel mixture in the cylinder.

The ground terminals on the magnetos are connected to magnetic switch **(6)** on instrument panel **(10)**. Manual stop switch **(7)** and stationary contacts in oil pressure gauge **(8)** and water temperature gauge **(9)** are also connected to magnetic switch **(6)**.

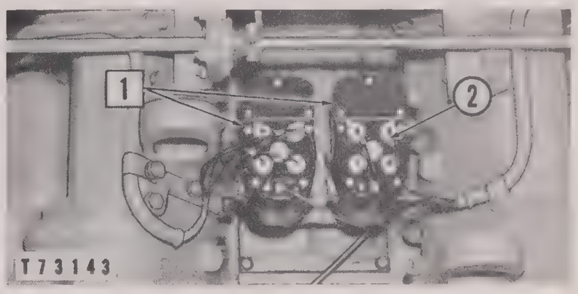
In the event of high coolant temperature or low oil pressure, the gauge pointer touches the stationary contacts to ground the magnetic switch and magnetos, thereby stopping the engine.

MAGNETO (American Bosch)

Removal and Installation

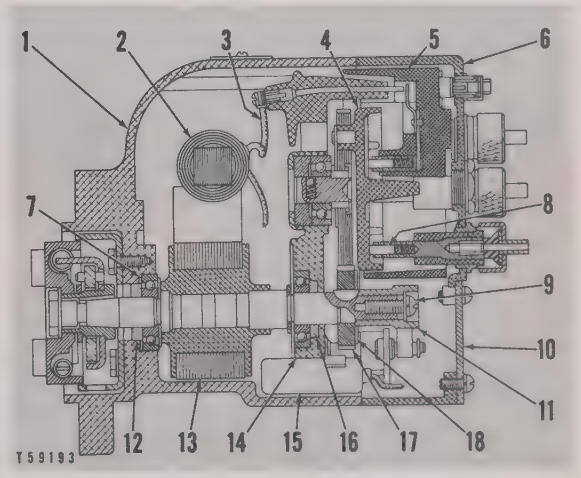
Place identification marks on leads **(2)** and disconnect them from magneto.

Install magnetos on engine. See topic, TIMING MAGNETOS TO ENGINE.



PREPARING TO REMOVE MAGNETOS
(G379 Illustrated)
1–Magnetos. 2–Leads.

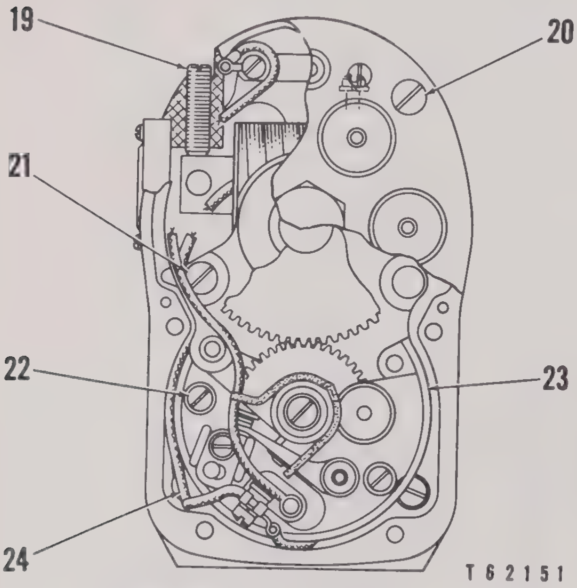
Disassembly and Assembly



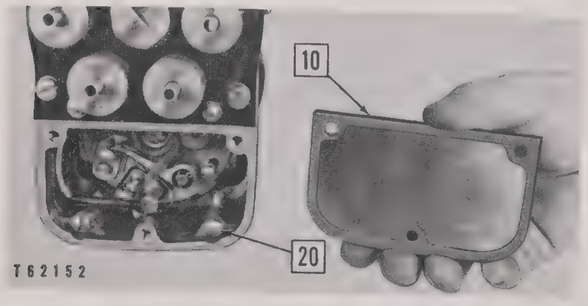
MAGNETO CROSS SECTION

1–Housing. 2–Coil assembly. 3–Wire. 4–Distributor gear and rotor assembly. 5–Insulation ring. 6–Cover assembly. 7–Bearing. 8–Brushes. 9–Screw and washer. 10–End cap. 11–Cam. 12–Washer. 13–Rotor shaft assembly. 14–Bracket assembly. 15–Condenser. 16–Washer. 17–Gear and key. 18–Indicating washer.

1. Disconnect ground wire **(24)** and remove cover assembly **(6)**, insulation ring **(5)** and brushes **(8)** as a unit.
2. Remove contact points. See topic, CONTACT POINT REMOVAL AND INSTALLATION.
3. Remove cam **(11)**.



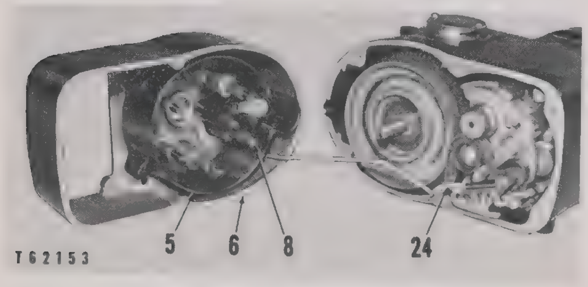
MAGNETO CROSS SECTION
19, 20, 21, and 22–Screw. 23–Plate assembly.
24–Ground wire.



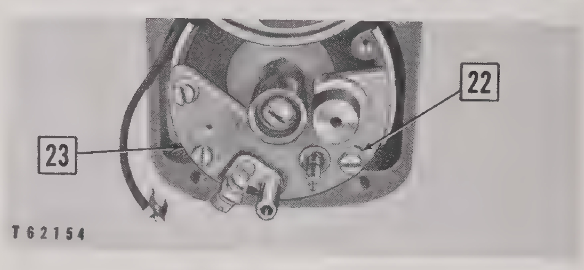
DISASSEMBLING MAGNETO

☐ Remove

10–End cap. 20–Screw (six).



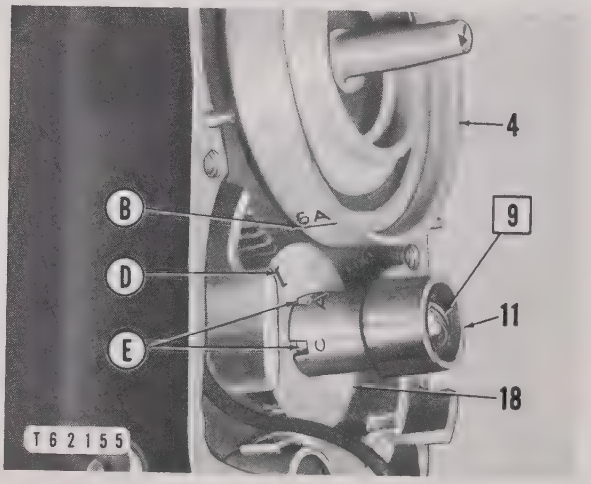
REMOVING COVER ASSEMBLY
5–Insulation ring. 6–Cover assembly. 8–Brushes.
24–Ground wire.



REMOVING PLATE ASSEMBLY

☐ Remove

22–Screws (two). 23–Plate assembly.



REMOVING CAM

☐ Remove

4–Distributor gear and rotor assembly. 9–Screw and washer. 11–Cam. 18–Indicating washer. B–Mark on distributor gear and rotor assembly. D–Mark on indicating washer. E–Slots in cam.

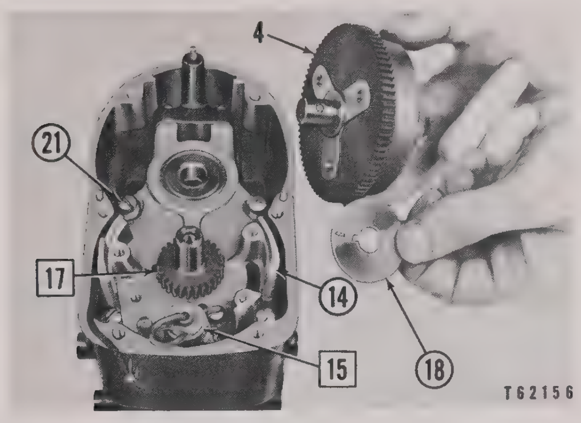
NOTE

Cam **(11)** has two slots **(E)**, one marked with letter "A" (anti-clockwise) and the other with letter "C" (clockwise). During assembly, engage the cam slot (marked with letter denoting rotation of magneto) with key on end of rotor shaft.

4. Remove distributor gear and rotor assembly **(4)** and indicating washer **(18)**.

NOTE

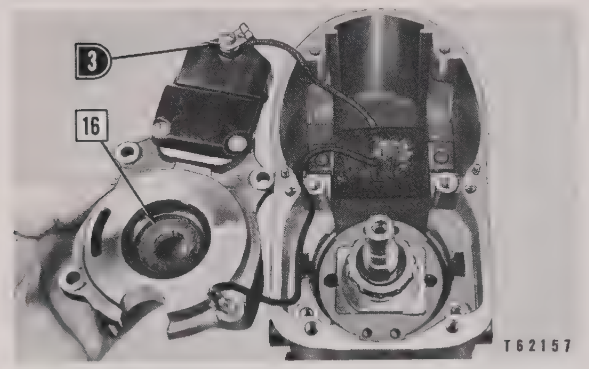
Distributor gear and rotor assembly **(4)** and indicating washer **(18)** must be removed simultaneously. During assembly, key slot in center of indicating washer **(18)** must engage key on rotor shaft. Slot **(D)** in outer rim of indicating washer must line up with one of the marks **(B)** on the distributor gear and rotor assembly. Distributor gear and rotor assembly **(4)** is marked "A" (anti-clockwise) and "C" (clockwise) and is aligned in accordance with direction of magneto rotation. For direction of magneto rotation, see topic, SPECIFICATIONS.



PREPARING TO REMOVE BRACKET ASSEMBLY

☐ Remove

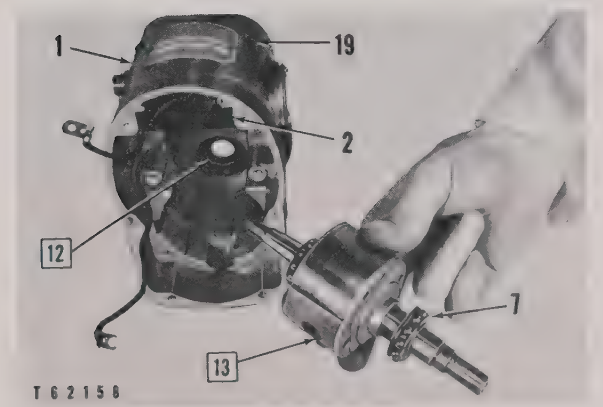
4–Distributor gear and rotor assembly. 14–Bracket assembly. 15–Condenser. 17–Gear and key. 18–Indicating washer. 21–Screws (four).



REMOVING BRACKET ASSEMBLY

☐ Remove ◗ Disconnect

3–Wire. 16–Washer.



REMOVING ROTOR SHAFT

☐ Remove

1–Housing assembly. 2–Coil assembly. 7–Bearings. 12–Washer. 13–Rotor shaft assembly. 19–Screws (two).

5. Remove screws **(21)** and separate bracket assembly **(14)** from housing.
6. Remove impulse coupling.
7. Loosen screws **(19)**, remove coil assembly **(2)**.

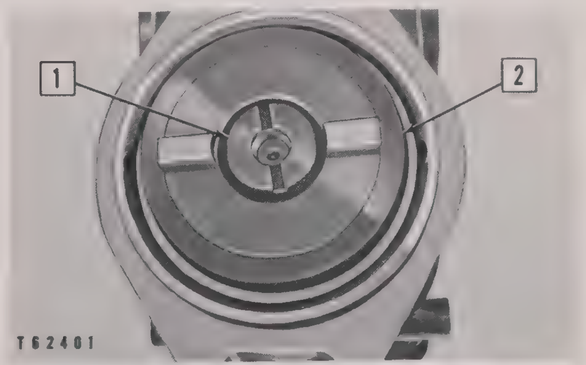
NOTE

During assembly, coat lower halves of screws **(19)** with white lead and upper protruding portion with air-drying black enamel. Tips of screws **(19)** are piloted into ends of the coil assembly for proper positioning.

8. Bearings **(7)** can be pressed from rotor shaft.
9. Bearing outer races can be pressed from housing **(1)** and bracket assembly **(14)**. When installing, an insulation strip must be placed between each outer race and the wall of bearing seat. Any excess material can be removed with a sharp instrument after race has been seated properly.
10. Inspect all parts. See topic, MAGNETO CLEANING AND INSPECTION.
11. Assemble in reverse order of disassembly.
12. Adjust contact points to proper opening. See topic, ADJUSTING CONTACT POINT OPENING.
13. Set magneto edge gap.

Impulse Coupling

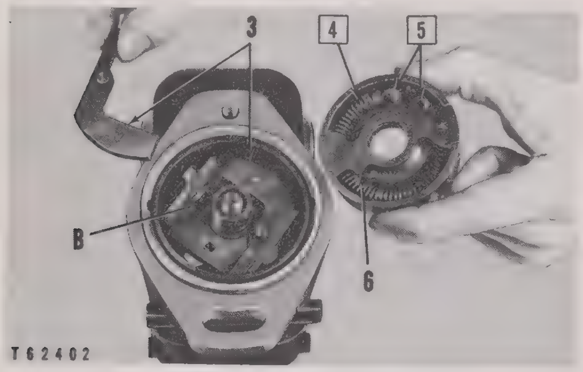
The impulse coupling is installed on the rear of the magneto. It provides the means for retarding spark automatically during starting period and intensifies the spark at low rotative speeds.



PREPARING TO DISASSEMBLE IMPULSE COUPLING

☐ Remove

1–Nut. 2–Housing assembly.



DISASSEMBLING IMPULSE COUPLING
(Anti-clockwise rotation magneto shown)

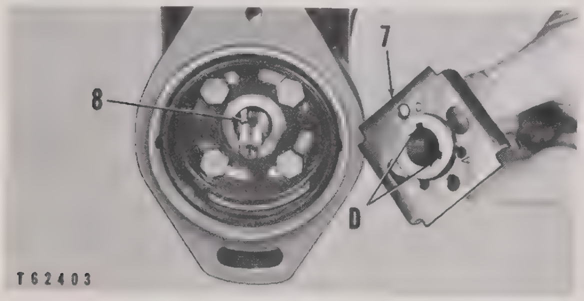
☐ Remove

3–Weights. 4–Spring. 5–Balls. 6–Cam. B–Slot.

1. Remove weights **(3)** from slots **(B)** and cam **(6)** from housing assembly.

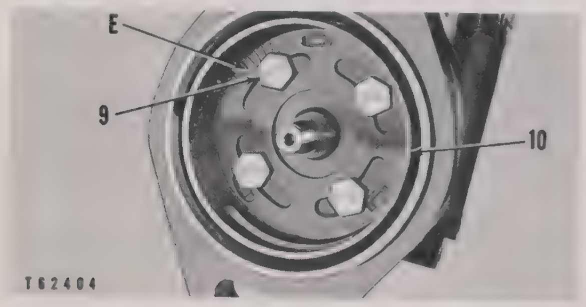
NOTE

Cam **(6)** and weights **(3)** have letter "A" (anti-clockwise) marked on one side and letter "C" (clockwise) marked on other side. Cam **(6)** and weights **(3)** must be assembled with appropriate letter visible, as shown, denoting direction of magneto rotation. For direction of magneto rotation, see topic, SPECIFICATIONS.



REMOVING HUB
7–Hub. 8–Key. D–Keyslots.

2. Remove hub **(7)** and key **(8)** from shaft.



REMOVING PLATE
(40° Lag angle impulse coupling shown)
9–Bolts. 10–Plate. E–Calibrations.

NOTE

Keyslots **(D)** are marked "A" (anti-clockwise) and "C" (clockwise). During assembly, keyslot with the letter denoting direction of magneto rotation must be aligned with key **(8)**. For direction of magneto rotation, see topic, SPECIFICATIONS.

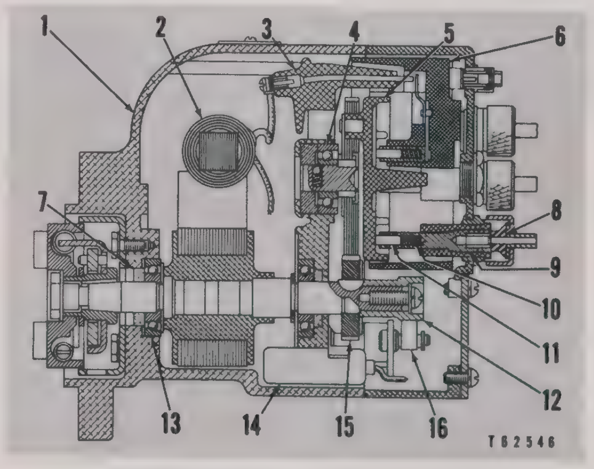
3. Plate **(10)** can be removed, if necessary, by removing bolts **(9)**.

NOTE

Plate **(10)** has calibrations **(E)** at 5° intervals from 0° to 50° for setting lag angle. Before removing plate **(10)** or bolts **(9)**, this setting should be noted to insure proper assembly.

4. Inspect all parts.
5. Assemble in reverse order of disassembly.
6. Tighten nut **(1)** to the torque value listed in the topic, SPECIFICATIONS.

Magneto Cleaning and Inspection



MAGNETO CROSS SECTION
1–Housing. 2–Coil assembly. 3–Low tension conductor. 4–Bearing. 5–Distributor gear and rotor assembly. 6–Insulation ring. 7–Washer. 8–Insulation bushing. 9–Low tension conductor terminal. 10–Spring. 11–Brush. 12–Cam. 13–Bearing. 14–Condenser. 15–Magnet rotor gear. 16–Lever assembly.

All metal parts except distributor gear shaft bearing **(4)** should be cleaned in mineral spirits and dried thoroughly. Bearing **(4)** and all insulated parts such as distributor gear and rotor assembly **(5)**, conductor terminals **(9)**, low tension conductor **(3)**, etc., should be wiped with a clean dry cloth.

VISUAL INSPECTION

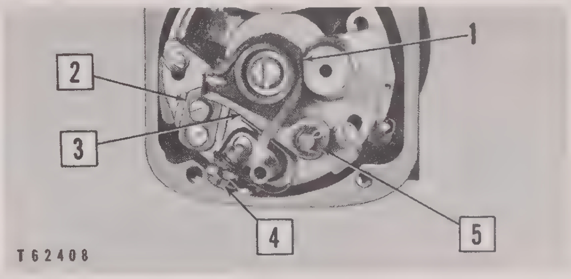
Part	Inspect For
Washer **(7)**	Worn or frayed condition — Lubrication.
Ball bearing **(4)**	Wear-roughness. Do not re-lubricate.
Ball bearings **(13)**	Wear-roughness and lubrication.
Ground cable	Loose terminal connection, frayed or worn insulation.
Distributor gear and rotor assembly **(5)**	Wear, cracks, brush tracks, worn or damaged teeth, loose rotor, and lubrication.
Insulation ring **(6)**	Cracks, corroded brass insert, corrosion on and security of contact spring, and cleanliness.
Brush **(11)** and spring **(10)**	Worn brush, damaged spring, cleanliness.
Contact points	Mounds, craters, cleanliness. If necessary, dress with a suitable stone. Do not use sandpaper or a file.
Lever assembly **(16)**	Wear, freedom of movement, and tension of spring. (Contact pressure 16 to 20 ounces).
Breaker lever insulation bushing	Cracks or damage.
Cam wick	Worn, frayed or hardened condition. Do not relubricate, replace if necessary.
Cam **(12)**	Wear.
Condenser **(14)**	Loose cable connections.
Coil assembly **(2)**	Loose wrapping, cleanliness. If wrapping is loose, brush only with air drying insulating varnish requiring an alcohol thinner.
Housing **(1)**	Cleanliness.
Housing ventilators	Cleanliness.
Cables	Frayed or cracked insulation.
Magnet rotor gear **(15)**	Burrs, worn teeth.
Low tension conductor **(3)**	Cracks, damage, cleanliness.
Low tension conductor terminal **(9)**	Cracks, cleanliness.
Insulation bushing **(8)**	Cracks, damage.

ELECTRICAL INSPECTION

Part	Test For
Coil assembly **(2)**	Continuity
Breaker plate assembly	Leakage between the insulated terminal bracket and breaker plate.
Cables	Continuity.
Insulation ring **(6)**	Leakage with a high-voltage spark.
Condenser **(14)**	Leakage, open or short circuit.
Distributor gear and rotor assembly **(5)**	Leakage or short circuit between electrode and shaft with a high-voltage spark.
Low tension conductor **(3)**	Leakage with a high-voltage spark.
Low tension conductor terminal **(9)**	Leakage with a high-voltage spark.

Contact Point Removal and Installation

1. Loosen screw **(4)**.



REMOVING CONTACT POINTS

☐ **Remove**

1–Cam wick. 2–Bracket. 3–Lever assembly. 4–Screw. 5–Pin and washer.

2. Cam wick **(1)** can be removed from lever assembly **(3)** after lever assembly has been removed.
3. Inspect cam wick **(1)**. See topic, MAGNETO CLEANING AND INSPECTION.

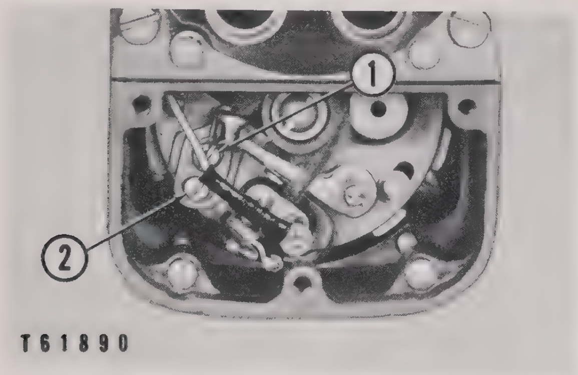
NOTE

Do not lubricate cam wick. Replace it when necessary. Be sure to remove any lubricant which may reach contact points during cam wick replacement. This is important as one of points is passed through wick when assembling it to breaker lever.

4. Inspect contact points. See topic, MAGNETO CLEANING AND INSPECTION.
5. Install in reverse order of removal.
6. Adjust contact points to proper setting. See topic, ADJUSTING CONTACT POINT OPENING.

Adjusting Contact Point Opening

1. Remove magneto end plate. Rotate magneto until contact point bumper block is on one of highest elevations of cam.
2. Loosen screw **(1)** which holds adjustable contact point bracket.



ADJUSTING CONTACT POINTS
1–Screw. 2–Slotted-head eccentric screw.

3. Insert a screwdriver in slotted-head eccentric screw **(2)** and turn until correct point opening is obtained. See topic, SPECIFICATIONS.
4. Tighten screw **(1)** and recheck adjustment.
5. Install magneto end plate.

Magneto Edge Gap

Maximum ignition discharge is obtained by interrupting the primary circuit at the instant the primary circuit reaches its maximum value. This point is reached when the rotor pole shoe is .100″ past the housing field. At this point, the contact points should just be beginning to open.

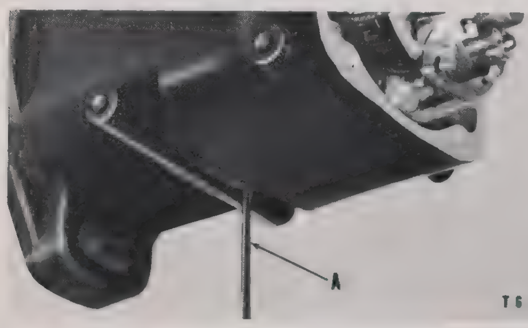
Adjustment:

1. Check contact point adjustment.

NOTE

Edge gap adjustment is independent of contact point adjustment; however, contact points must be set properly prior to edge gap adjustment.

2. Remove adjusting hole screw in bottom of magneto and insert a .100″ dia. rod **(A)** in hole as shown. When viewed from driving end, insert rod in left hand hole for anti-clockwise rotation magnetos and in right hand hole for clockwise rotation magnetos.

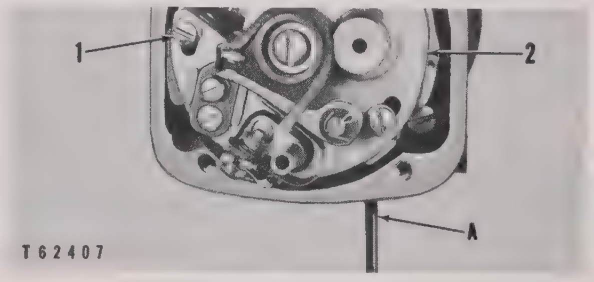


EDGE GAP ADJUSTMENT OPENINGS
A–.100″ dia. rod.

NOTE

The arrow on magneto identification plate (denoting direction of rotation) points to hole to be used.

3. Press rod inward until it contacts rotor shaft.
4. Turn rotor in direction opposite to normal rotation until rod locks tight between rotor pole shoe and housing field.
5. With rotor in this position, loosen support plate adjusting screws **(1)**.



ADJUSTING EDGE GAP
1–Adjusting screws (two). 2–Support plate.
A–.100″ dia. rod.

6. Move support plate **(2)** either left or right until contact points just start to open. Tighten support plate adjusting screws **(1)** securely.

NOTE

The point of initial contact point opening can be determined by inserting a thin piece of cellophane between the points, by using a timing light, or by use of a sounding device.

7. Recheck adjustment.
8. Remove rod and replace adjusting hole screw.

Timing Magnetos to Engine

1. Remove the timing pointer cover from the right side of the flywheel housing.
2. Rotate crankshaft in direction of engine rotation until No. 1 piston is coming up on compression stroke.
3. Continue rotating crankshaft until desired timing mark appears directly under flywheel pointer. See the SPECIFICATIONS.
4. With the right bank magneto off engine, remove end plate to expose breaker points and remove observation hole plug.

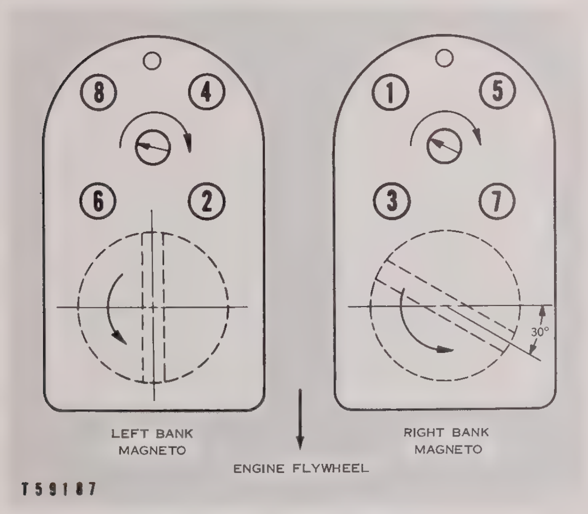
NOTE

Check magneto point gap and adjust if gap is not within limits of value given in the SPECIFICATIONS. See topic, ADJUSTING CONTACT POINT OPENING.

5. Rotate coupling until the arrow is in same relative position to No. 1 low tension outlet as shown. Drive tang should be in position shown (as viewed from tower end, through magneto):

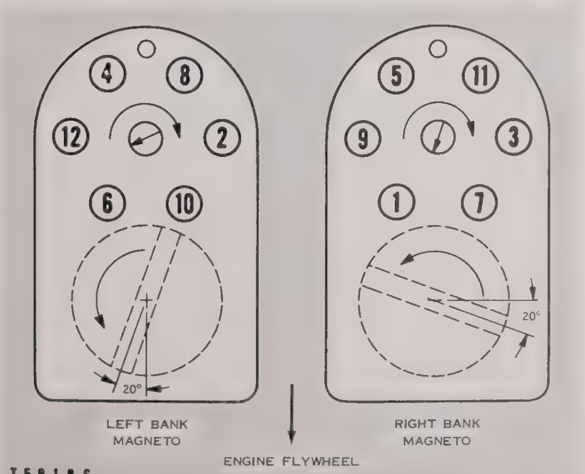
NOTE

To avoid engaging impulse weights, rotate coupling so point of arrow, as viewed through observation hole, moves in counterclockwise direction.



T59187

POSITION OF ARROW AND DRIVE TANG (G379)



T59186

POSITION OF ARROW AND DRIVE TANG (G398)

6. With No. 1 piston in proper firing position, right bank magneto drive slot should be in position to mesh with drive tang.

NOTE

If drive slot is not in this position, pull it forward, position it, and engage gear teeth.

7. Install right bank magneto to magneto drive housing, leaving mounting bolts loose. Approximate timing to engine is now obtained.
8. Cylinder No. 8 on G379 or No. 12 on G398 Engines, in the left bank fires next after cylinder No. 1 in the right bank. To time the left bank magneto to the engine, first turn the flywheel from the No. 1 cylinder firing position in the direction of normal engine rotation (CCW viewed from flywheel end) until the desired timing mark comes under the pointer attached to the flywheel housing.
9. With left bank magneto off engine, remove end plate to expose breaker points and remove observation hole plug.

NOTE

Check magneto point gap and adjust gap if it is not within limits of value given in the SPECIFICATIONS. See topic, ADJUSTING CONTACT POINT OPENING.

10. Rotate coupling until the arrow is in same relative position to No. 8 (G379) or No. 12 (G398) low tension outlet as shown. Drive tang should be in position shown (as viewed from tower end, through magneto).

NOTE

To avoid engaging impulse weights, rotate coupling so point of arrow, as viewed through observation hole, moves in counterclockwise direction.

11. With No. 8 (G379) or No. 12 (G398) piston in proper firing position, left bank magneto drive slot should be in position to mesh with drive tang.

NOTE

If drive slot is not in this position, pull it forward, position it, and engage gear teeth.

12. Install left bank magneto to magneto drive housing, leaving mounting bolts loose. Approximate timing to engine is now obtained.
13. Use a timing light to obtain exact timing of the magnetos. Mark the desired timing mark on the flywheel with chalk or white paint to make it more visible under the timing light.

14. Connect the timing light in series with the spark plug in cylinder No. 1 to time the right bank of the engine.

CAUTION

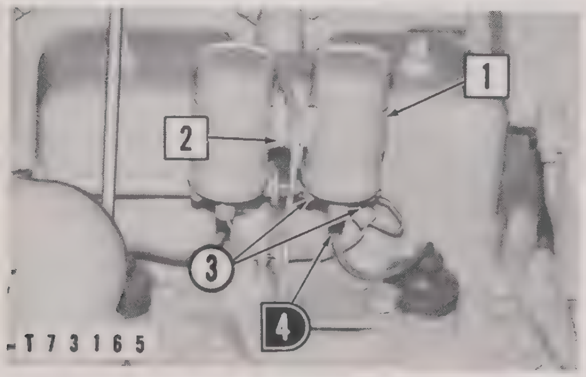
Do not puncture spark plug wire insulation. Use a jumper wire to connect timing light.

15. With the engine running, rotate the magneto housing on the drive housing to advance or retard the timing.
16. When the magneto is properly timed to the engine, as indicated by the light flashing on the chalk mark, tighten the mounting bolts securely.
17. Connect the timing light in series with the spark plug in cylinder No. 8 (G379 Engines), or cylinder No. 12 (G398 Engines).
18. Time the left bank of the engine in the same manner as timing the right bank.

IGNITION TRANSFORMER

Removal and Installation

1. Disconnect wires from terminals **(3)**.



REMOVING IGNITION TRANSFORMERS
1–Ignition transformer. 2–Bolt (two). 3–Terminals. 4–High tension lead.

NOTE

The remaining transformers are removed in a similar manner.

2. Inspect transformers, connections and terminals for dirt or corrosion and clean as necessary.
3. Measure the resistance of primary and secondary circuits. The value obtained should be compared with that of a transformer that is known to be good. Replace if necessary.
4. Install in reverse order of removal.

NOTE

On G379 engines, the positive (+) posts of No's 3, 4, 5 and 6 transformers are grounded, while the negative (−) posts of No's 1, 2, 7 and 8 are grounded.

On G398 engines, the positive (+) posts of No's 7, 8, 9, 10, 11 and 12 transformers are grounded, while the negative (−) posts of No's 1, 2, 3, 4, 5 and 6 are grounded.

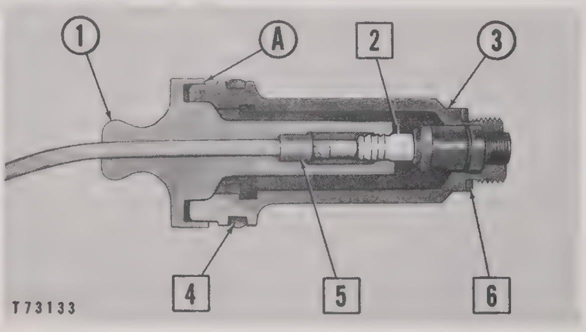
SPARK PLUGS, COVERS AND ADAPTERS

Removal and Installation

Remove the cover **(1)** from the spark plug **(2)** and the adapter **(3)**.

NOTE

Do not peel lip **(A)** from adapter. Grasp cover by handle and pull upward.

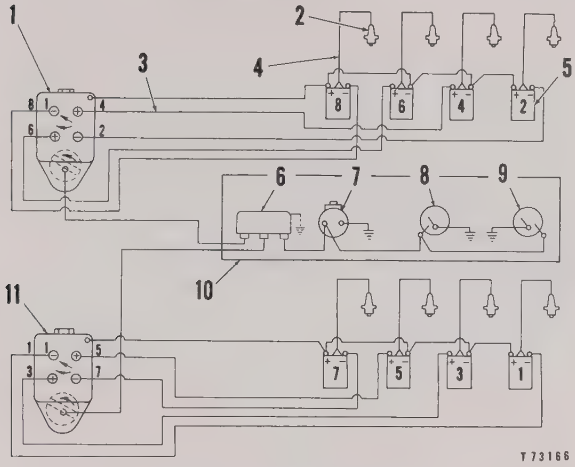


SPARK PLUG, COVER AND ADAPTER
(Cross Section Shown For Better Illustration)
1–Cover. 2–Spark plug. 3–Adapter. 4–Seal. 5–Spacer. 6–Gasket. A–Lip.

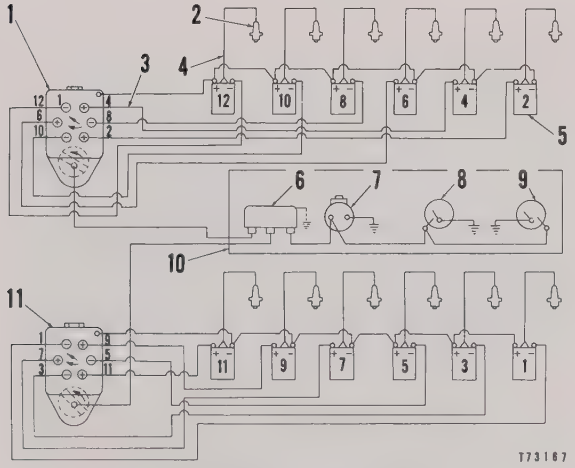
Inspect spark plugs for damaged insulation or electrodes and proper gap. See SPECIFICATIONS.

Coat seal groove of adapter **(3)** and seal **(4)** with liquid soap. Install adapter into cylinder head and tighten to torque value given in the SPECIFICATIONS.

INTRODUCTION



G379 IGNITION SYSTEM
1–Left bank magneto. 2–Spark plugs. 3–Low tension leads. 4–High tension leads. 5–Transformers. 6–Magnetic switch. 7–Manual stop switch. 8–Oil pressure gauge. 9–Water temperature gauge. 10–Instrument panel. 11–Right bank magneto.



G398 IGNITION SYSTEM
(Nomenclature same as previous illustration)

The ignition system consists of low tension magnetos **(1)** and **(11)**, ignition transformers **(5)**, low and high tension leads **(3)** and **(4)**, spark plugs **(2)** and a magnetic shutoff switch **(6)**.

Magnetos **(1)** and **(11)** generate primary voltage and deliver it through low tension leads **(3)** to ignition transformers **(5)**. The transformers boost the voltage induced by the magnetos and delivers this electrical surge through high tension leads **(4)** to spark plugs **(2)**. The spark plug ignites the air/fuel mixture in the cylinder.

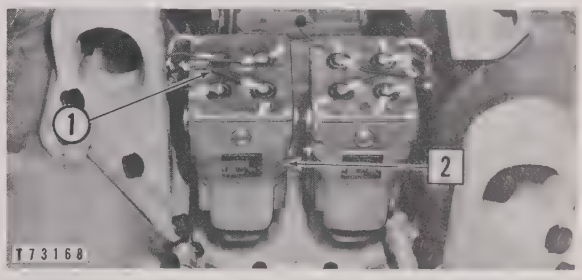
The ground terminals on the magnetos are connected to magnetic switch **(6)** on instrument panel **(10)**. Manual stop switch **(7)** and stationary contacts in oil pressure gauge **(8)** and water temperature gauge **(9)** are also connected to magnetic switch **(6)**. In the event of high coolant temperature or low oil pressure, the gauge pointer touches the stationary contacts and grounds the magnetic switch and magnetos, thereby stopping the engine.

MAGNETO (Fairbanks-Morse)

Removal and Installation

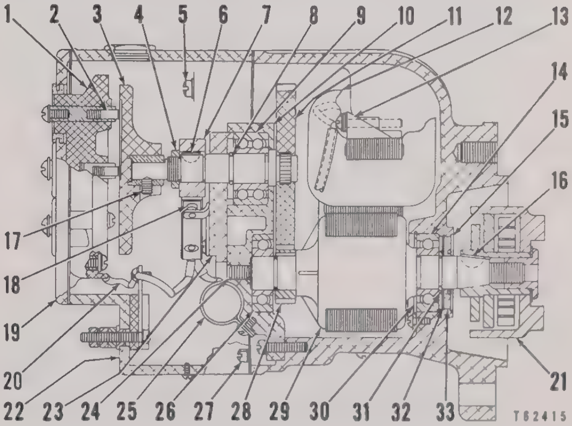
Place identification marks on leads **(1)** and disconnect them from magnetos **(2)**.

Install magnetos to engine. See topic, TIMING MAGNETOS TO ENGINE.



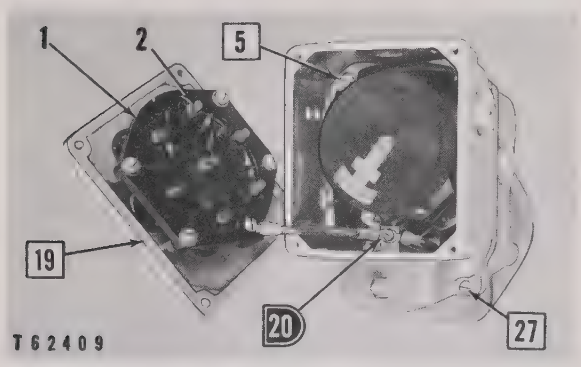
PREPARING TO REMOVE MAGNETOS
(G379 Illustrated)
1–Leads. 2–Magneto.

Disassembly and Assembly



MAGNETO CROSS SECTION
1–Distributor block. 2–Brush and spring assembly. 3–Distributor disc. 4–Nut. 5–Screw. 6–Key. 7–Cam. 8–Lock ring. 9–Bearing. 10–Bearing support. 11–Distributor gear and shaft assembly. 12–Coil. 13–Wedge and screw. 14–Bearing. 15–Outer washer. 16–Key. 17–Setscrew. 18–Contact points. 19–End cap cover. 20–Wire. 21–Impulse coupling. 22–End cap. 23–Support bracket. 24–Setscrew. 25–Condenser. 26–Bearing. 27–Screw. 28–Rotor shaft pinion. 29–Rotor shaft assembly. 30–Washer. 31–Lock ring. 32–Inner washer. 33–Seal.

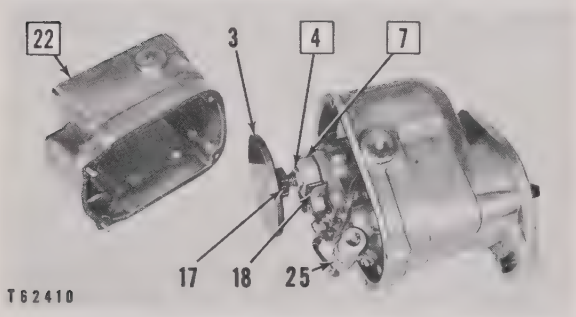
1. Inspect brush and spring assembly **(2)** in distributor block **(1)**. They should move freely and be under slight spring pressure.
2. Loosen setscrew **(17)** and remove distributor disc **(3)**. Wipe distributor disc with a clean cloth moistened in petroleum solvent.
3. Remove contact points **(18)**.
4. Remove condenser **(25)**. Clean lead wire and cam. Test for open circuit.



REMOVING END CAP

☐ Remove ◗ Disconnect

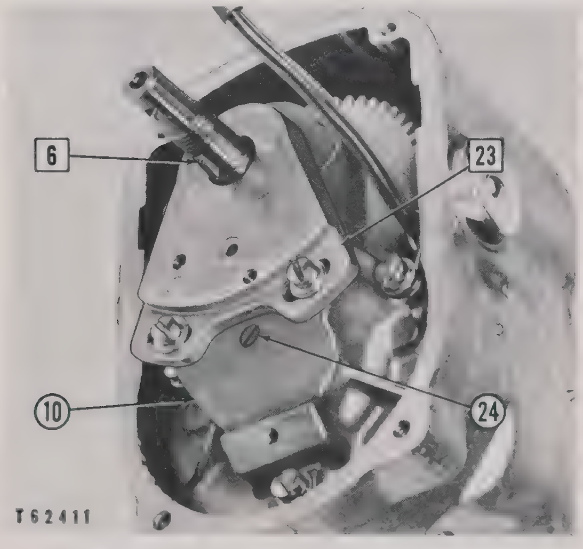
1–Distributor block. 2–Brush and spring assembly. 5–Screw (two). 19–End cap cover. 20–Wire. 27–Screw (two).



DISASSEMBLING MAGNETO

☐ Remove

3–Distributor disc. 4–Nut. 7–Cam. 17–Setscrew. 18–Contact points. 22–End cap. 25–Condenser.



PREPARING TO REMOVE BEARING SUPPORT

☐ Remove

6–Key. 10–Bearing support. 23–Support bracket. 24–Setscrew.

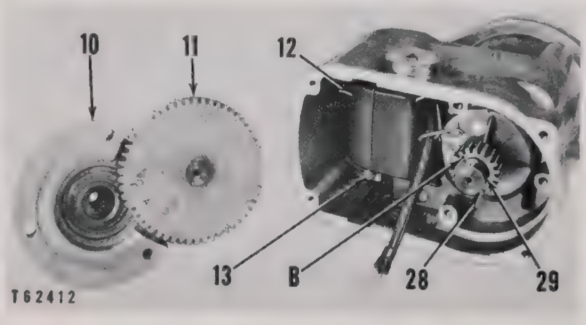
NOTE

Cam **(7)** has two keyslots, one for each direction of magneto rotation. Each keyslot is marked with an arrow denoting direction of rotation. During assembly, engage key **(6)** with proper keyslot in accordance with direction of magneto rotation. For direction of magneto rotation, see topic, SPECIFICATIONS.

5. Remove bearing support screws. Insert a ¼"-20 NC forcing screw 1½" long in place of setscrew **(24)** and remove bearing support **(10)**. During assembly, coat threads of setscrew **(24)** with shellac. Turn setscrew in until head is flush with bearing support.

NOTE

Distributor gear and shaft assembly **(11)** has letters "A" (anti-clockwise) and "C" (clockwise) marked on it. During assembly, align the letter denoting direction of magneto rotation with marked tooth **(B)** on rotor shaft pinion **(28)**. For direction of magneto rotation, see topic, SPECIFICATIONS.



REMOVING BEARING SUPPORT

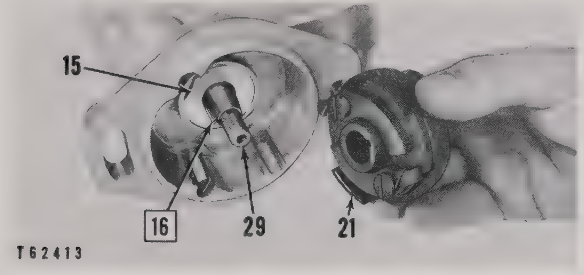
10–Bearing support. 11–Distributor gear and shaft assembly. 12–Coil. 13–Coil wedge and screw. 28–Rotor shaft pinion. 29–Rotor shaft assembly. B–Marked tooth on rotor shaft pinion.

6. Inspect bearing support **(10)** and bearings **(9)** and **(26)**. If bearing support or either bearing shows signs of wear, the entire bearing support must be replaced.
7. Distributor gear and shaft assembly **(11)** can be removed from bearing support **(10)**. Remove lock ring **(8)** and press from bearing support.
8. Loosen coil wedge and screws **(13)** and turn rotor shaft assembly **(29)** until flux lock is broken. Slide coil **(12)** from housing. Inspect for cleanliness. Test for continuity.

NOTE

Coil **(12)** has two leads. During assembly, shorter lead should be fastened under left coil wedge screw. Longer lead should be fastened to breaker arm terminal screw.

9. Remove impulse coupling **(21)**.

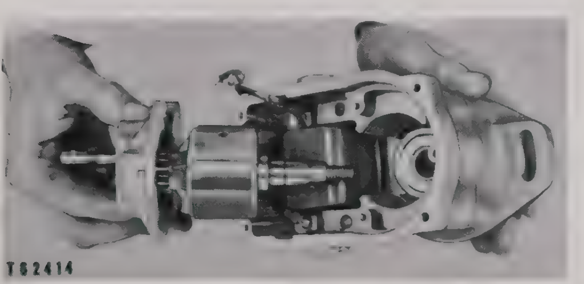


PREPARING TO REMOVE ROTOR SHAFT ASSEMBLY

☐ **Remove**

15–Outer washer. 16–Key. 21–Impulse coupling. 29–Rotor shaft assembly.

10. Remove outer washer **(15)** and seal **(33)** and inner washer **(32)** beneath it.
11. Remove lock ring **(31)** and press rotor shaft assembly from housing.
12. Remove washer **(30)** and press bearing **(14)** from housing.
13. Inspect all parts.
14. Assemble in reverse order of disassembly.
15. To install rotor shaft assembly **(29)**:
    a. Assemble distributor gear and shaft assembly **(11)** to bearing support **(10)**. Install lock ring **(8)**.
    b. Align marked tooth **(B)** on rotor shaft pinion **(28)** with proper tooth on distributor gear and shaft assembly **(11)** for proper direction of magneto rotation. For direction of magneto rotation, see topic, SPECIFICATIONS.
    c. Press rotor shaft assembly **(29)** into bearing support **(10)**.
    d. Install rotor shaft assembly and bearing support as a unit.



INSTALLING BEARING SUPPORT AND ROTOR SHAFT ASSEMBLY

    e. Press rotor shaft assembly **(29)** into housing and install lock ring **(31)**, seal **(33)**, and washers **(15)** and **(32)**. Do not install impulse coupling **(21)** until edge gap and contact point adjustments have been made.

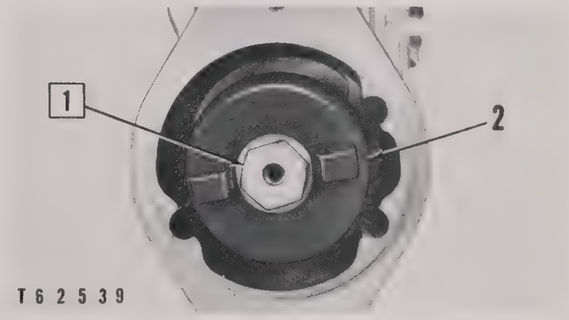
NOTE

Insert a 3/16" rod 3" long in place of setscrew **(24)**. Press against end of rod to install rotor shaft assembly.

16. Adjust contact points. See topic, CONTACT POINTS.
17. Adjust edge gap setting. See topic, EDGE GAP.

Impulse Coupling

The impulse coupling is installed on the rear of the magneto. It provides the means for retarding the spark automatically during the starting period and intensifies the spark at low rotative speeds.

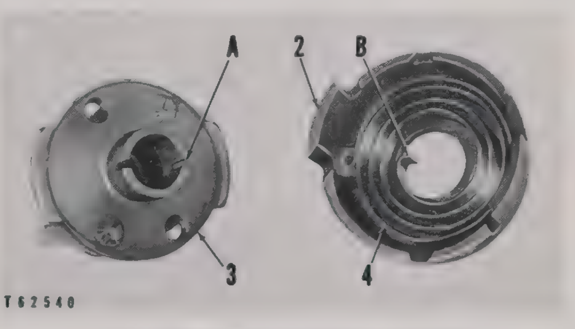


PREPARING TO DISASSEMBLE IMPULSE COUPLING

☐ **Remove**

1–Nut and washer. 2–Coupling shell.

1. Grasp one of drive lugs of coupling shell **(2)** firmly with a pair of pliers. Turn and pull coupling shell at same time until spring **(4)** releases.



DISASSEMBLING IMPULSE COUPLING
(Clockwise rotation magneto shown)
2–Coupling shell. 3–Hub assembly. 4–Spring. A–Anchor slot. B–Spring end.

NOTE

Do not force coupling shell **(2)** to separate entirely from hub assembly **(3)**. Spring end **(B)** should first be pried out of slot **(A)**.

2. Pull hub assembly **(3)** from shaft.
3. Remove spring **(4)** from coupling shell **(2)**.
4. Inspect all parts.
5. Clean and lubricate before reassembly.
6. Assemble spring **(4)** to coupling shell **(2)**.

NOTE

Spring **(4)** must coil in proper direction for magneto rotation. For clockwise rotation magnetos, spring **(4)** must coil counterclockwise from **(B)**, as shown. For counterclockwise, it must coil clockwise from **(B)**. For direction of magneto rotation, see topic, SPECIFICATIONS.

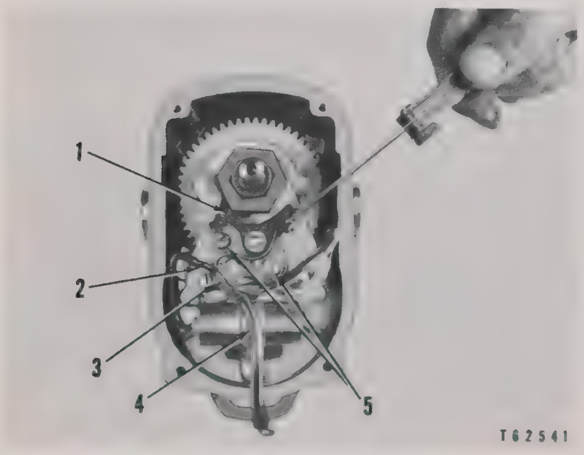
7. Position spring end **(B)** in anchor slot **(A)**.
8. Wind spring one full turn and push coupling shell **(2)** and hub assembly **(3)** together.
9. Install coupling shell **(2)** and hub assembly **(3)** as a unit to rotor shaft assembly. Install nut and washer **(1)**.

Contact Points

Inspect contact points for mounds, craters, cleanliness, rubbing block or contact wear. Replace if necessary. Points can be cleaned with a petroleum solvent. Oil and grease of any kind must be kept away from the points.

NOTE

The contact points cannot be separated and must be removed and installed as a set.



CONTACT POINTS
1–Breaker arm. 2–Wire. 3–Screw. 4–Wire. 5–Screws.

1. Remove contact point set:
   a. Remove screw **(3)**, wire **(2)** and wire **(4)**.
   b. Remove screws **(5)** which secure contact point set to support plate and remove.
2. Install in reverse order of removal.

NOTE

Do not relubricate cam wick. Replace if necessary.

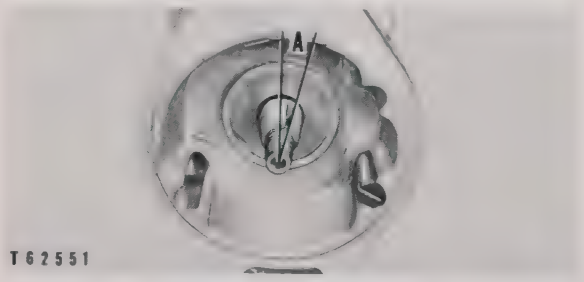
3. Adjust points to proper opening.
   a. Position high point of cam against arm **(1)**.
   b. Loosen screws **(5)**.
   c. Insert a thickness gauge between points as shown. See topic, SPECIFICATIONS, for proper gap opening.
   d. Move point set either left or right to obtain proper setting.
   e. Tighten screws **(5)** and recheck setting.

Magneto Edge Gap

Maximum ignition discharge is obtained by interrupting the primary circuit at the instant the primary circuit reaches its maximum value. This point is reached when the rotor pole shoe is 1/8″ past the housing field. At this point, the contact points should just be beginning to open.

Adjustment:

1. Check contact points and adjust to proper gap.
2. Remove impulse coupling.
3. Turn the rotor shaft so the keyway is up, then turn the shaft approximately 15° in direction of magneto rotation as shown. See topic, SPECIFICATIONS for direction of magneto rotation.



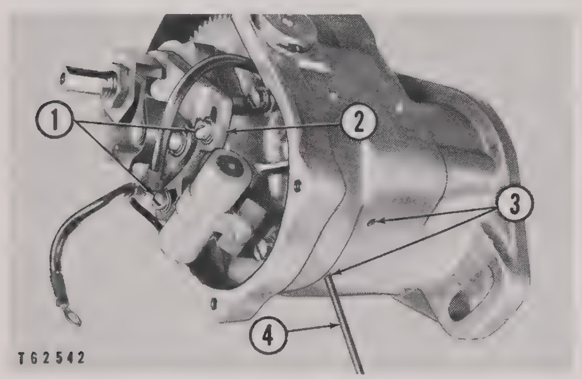
EDGE GAP ADJUSTMENT
(Clockwise rotation magneto shown)
A–15° angle.

4. View magneto from drive end. Remove setscrew and insert an 1/8″ rod **(4)** in timing hole **(3)**. Use right hole for clockwise rotation magnetos and left hole for counterclockwise rotation magnetos. Illustration shows rod **(4)** inserted in proper hole for clockwise rotation magneto.

NOTE

See the SPECIFICATIONS for direction of magneto rotation.

5. Loosen support plate screws **(1)**.
6. Press rod **(4)** inward until it contacts rotor. Turn rotor shaft in direction opposite normal rotation until rod locks tight between the rotor pole shoe and housing field.



EDGE GAP ADJUSTMENT
(Clockwise rotation magneto shown)
1–Support plate screws. 2–Support plate. 3–Timing holes. 4–Rod.

7. With rotor in this position, move plate **(2)** either left or right until contact points start to open. Tighten support plate screws **(1)** securely.

NOTE

The point of initial contact point opening can be determined by inserting a thin piece of cellophane between the points, by using a timing light, or by using a sounding device.

8. Install impulse coupling.

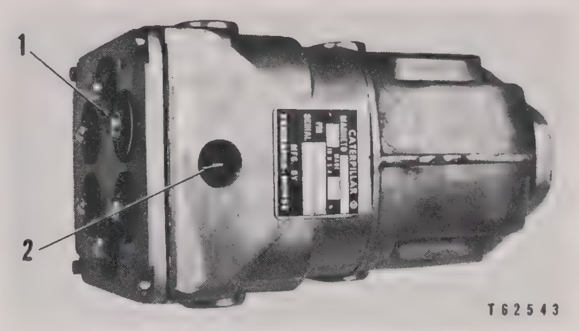
Timing Magnetos to Engine

1. Remove the cover from timing hole on the right side of the flywheel housing.
2. Rotate crankshaft in direction of engine rotation until No. 1 piston is coming up on the compression stroke.
3. Continue rotating crankshaft until desired timing mark appears directly under flywheel pointer. See topic, SPECIFICATIONS.
4. With right bank magneto off engine, remove timing bolt from top of magneto end cap.
5. Turn rotor shaft until timing mark **(2)** is centered in timing window. This indicates that terminal **(1)** is ready to fire.

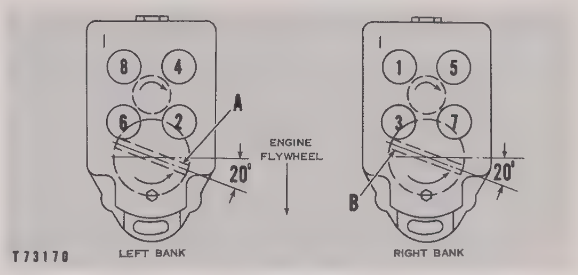
NOTE

Terminal **(1)** on right bank magnetos is of negative (−) polarity, located in upper left corner of end cap cover and is indicated by a mark on the cover.

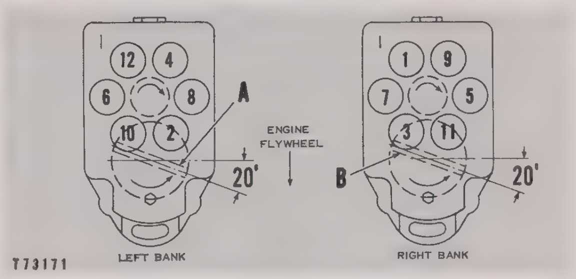
6. Drive tang **(B)** should be in position shown, as viewed through magneto from terminal end.



TIMING MARK ON DISTRIBUTOR DISC
1–Terminal. 2–Timing mark.



MAGNETO OUTLET NUMBERING DIAGRAM (G379)
A–Drive tang. B–Drive tang.



MAGNETO OUTLET NUMBERING DIAGRAM (G398)
A–Drive tang. B–Drive tang.

7. With No. 1 piston in proper firing position, drive slot should be in position to mesh with drive tang **(B)**.

NOTE

If drive slot is not in this position, pull drive shaft forward, position it, and engage gear teeth.

8. Install right bank magneto to magneto drive housing, leaving mounting bolts loose. Approximate timing to engine is now obtained.
9. Cylinder No. 8 on G379 or No. 12 on G398 Engines, in the left bank fires next after cylinder No. 1 in the right bank. To time the left bank magneto to the engine, first turn the flywheel from the No. 1 cylinder firing position in the direction of normal engine rotation (CCW viewed from flywheel end) until the desired timing mark comes under the pointer attached to the flywheel housing.

10. Continue rotating crankshaft until desired timing mark appears directly under flywheel pointer. See the SPECIFICATIONS.
11. With left bank magneto off engine, remove timing bolt from top of magneto end cap.
12. Turn rotor shaft until timing mark **(2)** is centered in timing window. This indicates that terminal **(1)** is ready to fire.

NOTE

Terminal **(1)** (No. 8 on G379 and No. 12 on G398) on left bank magnetos is of negative (−) polarity, located in the upper left corner of end cap and is indicated by a mark on the cover.

13. Drive tang **(A)** should be in position shown, as viewed through magneto from terminal end.
14. With No. 1 piston in proper firing position, drive slot should be in position to mesh with drive tang **(A)**.

NOTE

If drive slot is not in this position, pull drive shaft forward, position it, and engage gear teeth.

15. Install left bank magneto to magneto drive housing, leaving mounting bolts loose. Approximate timing to engine is now obtained.
16. Use a timing light to obtain exact timing of the magnetos. Mark the desired timing mark on the flywheel with chalk or white paint to make it more visible under the timing light.
17. Connect the timing light in series with the spark plug in cylinder No. 1 to time the right bank of the engine.

CAUTION

Do not puncture spark plug wire insulation. Use a jumper wire to connect timing light.

18. With the engine running, rotate the magneto housing on the drive housing to advance or retard the timing.
19. When the magneto is properly timed to the engine, as indicated by the light flashing on the chalk mark, tighten the mounting bolts securely.
20. Connect the timing light in series with the spark plug in cylinder No. 8 (G379 Engines), or cylinder No. 12 (G398 Engines).
21. Time the left bank of the engine in the same manner as timing the right bank.

IGNITION TRANSFORMER

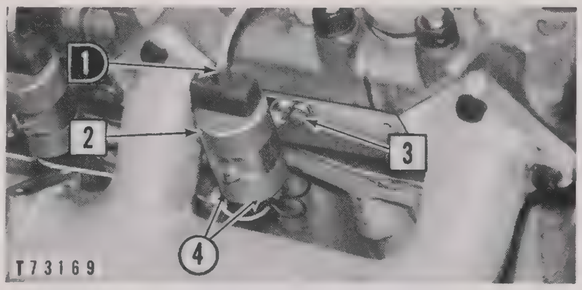
Removal and Installation

1. Disconnect wires from terminals **(4)**.

NOTE

The remaining transformers are removed in a similar manner.

2. Inspect transformers, connections, and terminals for dirt or corrosion. Clean as necessary.



REMOVING IGNITION TRANSFORMER
(G398 Illustrated)
1–High tension lead. 2–Ignition transformer. 3–Bolt (two). 4–Terminals.

3. Measure resistance of primary and secondary circuits. Compare the value obtained with that of a transformer known to be good.
4. Install in reverse order of removal.

NOTE

On G379 engines, the positive (+) posts of No's 1, 7, 8 and 2 transformers are grounded, while the negative (−) posts of No's 3, 4, 5 and 6 are grounded.

On G398 engines, the positive (+) posts of No's 1, 3, 5, 8, 10 and 12 transformers are grounded, while the negative (−) posts of No's 2, 4, 6, 7, 9 and 11 are grounded.

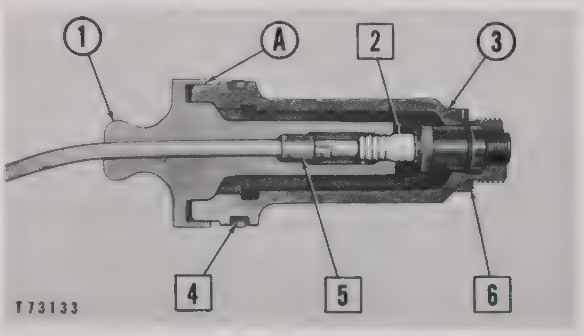
SPARK PLUGS, COVERS AND ADAPTERS

Removal and Installation

Remove the cover **(1)** from the spark plug **(2)** and the adapter **(3)**.

NOTE

Do not peel lip **(A)** from adapter. Grasp the cover by handle and pull upward.



SPARK PLUG, COVER AND ADAPTER
(Cross Section Shown For Better Illustration)
1–Cover. 2–Spark plug. 3–Adapter. 4–Seal. 5–Spacer. 6–Gasket. A–Lip.

Inspect spark plugs for proper gap and damaged insulation or electrodes. See the SPECIFICATIONS.

Coat seal groove of adapter **(3)** and seal **(4)** with liquid soap. Install adapter into cylinder head and tighten to torque value given in the SPECIFICATIONS.

INTRODUCTION

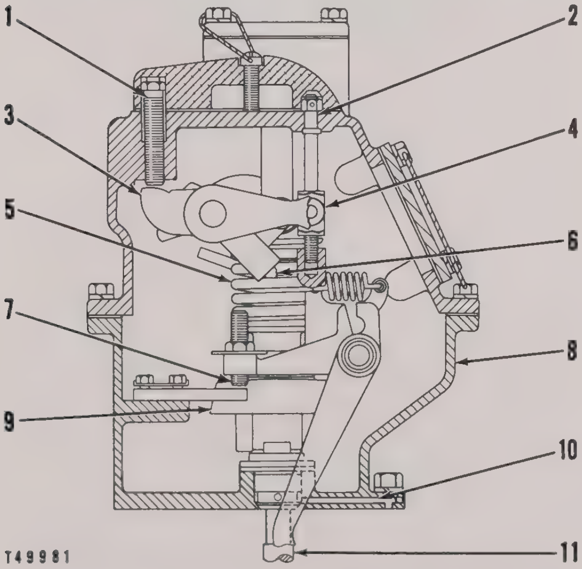
The governor is located in the V of the engine and is mounted on the fuel pump and governor drive housing. It is driven by a gear on the fuel injection pump and governor drive shaft.

Rack settings are carefully set at the factory and should not be changed without specific instructions to do so. An incorrectly adjusted fuel rack affects the operation of the turbocharger. See the topic, TURBOCHARGER ALTITUDE OPERATION.

The governor covers are sealed with wire. The governor mounting bolts are also sealed and the seal must be broken to remove the governor from the fuel pump and governor drive housing.

OPERATION AND LUBRICATION
(Mechanical)

The operator selects a desired engine speed by moving the governor control lever. The governor tends to maintain this desired engine speed selection under varying engine load conditions (as long as engine loads are not greater than the governor lever selection).

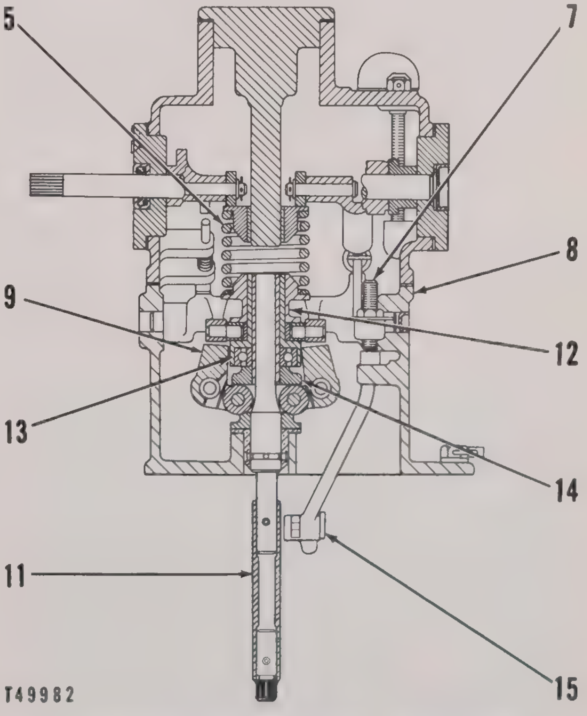


GOVERNOR CROSS SECTION — LEFT SIDE VIEW
1–High idle adjustment screw. 2–Low idle adjustment screw. 3–Stop. 4–Roller. 5–Spring. 6–Plunger. 7–Adjustment screw. 8–Lower housing. 9–Weights (two). 10–Oil passage. 11–Flexible spindle.

When the engine is operating, the compression force of governor spring **(5)** is always pushing to increase engine RPM while the centrifugal force of revolving governor weights **(9)** is always acting to decrease engine RPM. Engine RPM is regulated when the centrifugal force of the governor weights balances the compression force of the governor spring.

An increase in engine load will decrease engine RPM. Weights **(9)** will also turn slower causing a decrease in governor weight centrifugal force. With less centrifugal force to balance governor spring force, governor spring **(5)** can now increase the engine RPM by moving cage **(12)**, that will move lever **(15)** connected to the engine fuel rack, to an increased fuel position. At the same time the engine RPM increases, weights **(9)** swing out (as the weights turn faster) and the toes of the weights will move sleeve assembly **(14)**, bearing **(13)** and cage **(12)**, that moves lever **(15)** connected to the engine fuel rack, toward a lesser fuel position. When the centrifugal force of governor weights **(9)** again balances the force of governor spring **(5)**, the engine RPM will be the same as it was before the load increased.

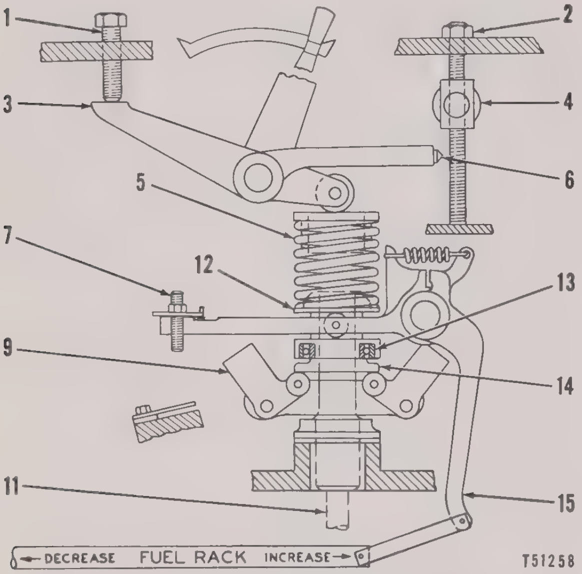
When engine load decreases, engine RPM increases; the governor weights turn faster and the weights swing out. The toes on the weights move the linkage (as previously explained) and the engine RPM decreases. When the centrifugal force of the governor weights again balances the force of the governor spring, the engine RPM will be the same as it was before the load decreased.



GOVERNOR CROSS-SECTION — FRONT VIEW
5–Spring. 7–Adjusting screw. 8–Lower housing. 9–Weights (two). 11–Flexible spindle. 12–Cage. 13–Bearing. 14–Sleeve assembly. 15–Lever assembly.

Adjustment screw **(7)** limits rack assembly travel. Stop **(3)** contacts high idle adjustment screw **(1)** to control the engine high idle RPM.

The governor weights are driven by flexible spindle **(11)**. This flexible spindle will smooth out torsional vibrations (that can occur in the fuel injection pump and governor drive shaft) and not allow these false signals to reach the governor weights.



GOVERNOR SET AT HIGH IDLE (SCHEMATIC)
1–High idle adjustment screw. 2–Low idle adjustment screw. 3–Stop. 4–Roller. 5–Spring. 6–Plunger. 7–Adjustment screw. 9–Weights (two). 11–Flexible spindle. 12–Cage. 13–Bearing. 14–Sleeve assembly. 15–Lever assembly.

When the governor control lever is moved to the low idle position, plunger **(6)** contacts the lower portion of roller **(4)**. As the governor control lever is moved still further to stop the engine, plunger **(6)** compresses a spring, permitting the plunger to retract and move above roller **(4)**, thus allowing lever **(15)** to move the fuel pump rack to the shut-off position. Adjusting screw **(2)** is used to adjust low idle RPM.

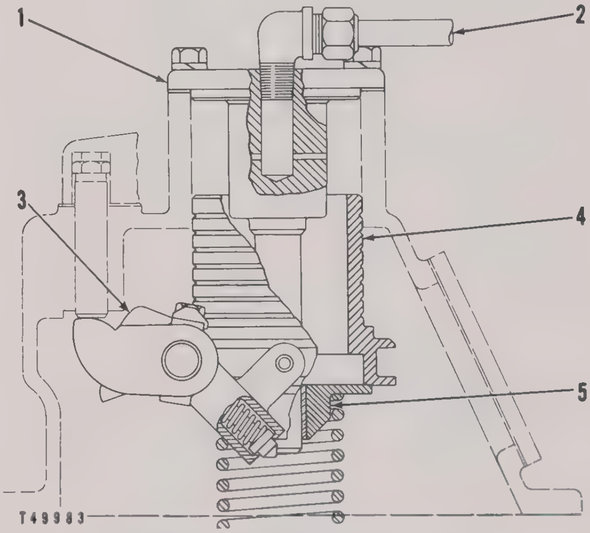
The governor is lubricated by oil from the engine lubricating system. Oil from a tube in the timing gear compartment supplies oil to a passage in the fuel pump and governor drive housing. The oil is directed through drilled passages to oil passage **(10)** in lower housing **(8)**. The oil then enters a groove and a drilled passage in flexible spindle **(11)** and is forced to the upper portion of the spindle where it is released through two cross-drilled passages to lubricate the various parts of the governor by splash. The oil drains back into the engine oil pan.

OPERATION AND LUBRICATION
(Hydraulic Servo Mechanism)

The operation and lubrication of the governor is not changed with the addition of the hydraulic servo mechanism. This unit assists the manual control for ease of operation.

The hydraulic servo mechanism is located entirely within the upper housing of the governor and is actuated by engine lubricating oil. Oil is delivered to cover **(1)** by external tube **(2)** and is under constant pressure while the engine is operating.

When the engine is operating, oil fills the cavity between the bottom face of cover **(1)** and spring retainer **(5)**, which also fills the cavity in piston **(4)**. When the engine is operating, the oil pressure will separate spring retainer **(5)** from piston **(4)** thus allowing a small amount of oil to escape.



HYDRAULIC SERVO MECHANISM
1–Cover. 2–Tube. 3–Lever assembly. 4–Piston. 5–Spring retainer.

By moving the governor control to increase engine RPM lever assembly **(3)** moves the piston down until it contacts the spring retainer, stopping the escape of the oil and causing the oil pressure to assist in compressing the governor spring. When the movement of the governor control is stopped, the oil pressure will again separate spring retainer **(5)** from piston **(4)** creating a small oil escape.

When returning the governor control to low idle, the piston is raised, creating a large gap and there is no oil pressure against the spring retainer, thus allowing the spring to return the spring retainer to its low idle position. A small amount of oil will continue to escape.

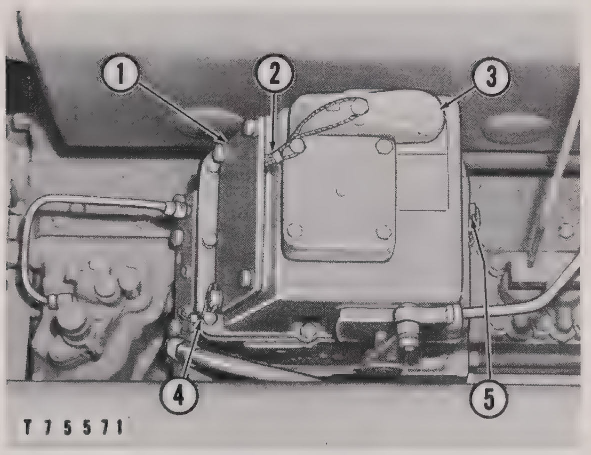
GOVERNOR SEALS

Rack adjusting screw cover **(1)**, governor idle speed cover **(3)**, the governor mounting bolts and the hydraulic servo mechanism cover, if so equipped, are sealed with wire.

To remove the governor from the fuel pump and governor drive housing, remove seal **(4)**.

NOTE

On engines equipped with a hydraulic servo mechanism, remove the wire seal from the servo mechanism cover to gain access.



GOVERNOR SEALS
1–Rack adjusting screw cover. 2–Seal. 3–Idle speed cover. 4–Seal. 5–Seal.

When preparing to adjust the high and low idle speeds, remove seal **(2)** and cover **(3)**. When preparing to adjust the rack setting, remove seal **(4)** and cover **(5)**.

Rack settings are carefully set at the factory and should not be changed without specific instructions. An incorrectly adjusted fuel rack affects the operations of the turbochargers. See the topic, TURBOCHARGER ALTITUDE OPERATION.

NOTE

The letters CT CO identify factory installed seals. Dealer's 6H4160 Sealing Tool Assembly impresses the letters DLR on the seals.

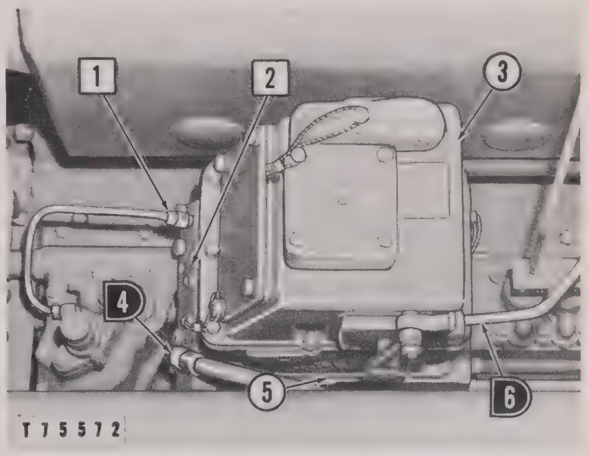
REMOVAL AND INSTALLATION

NOTE

Oil line **(1)** is used only on engines equipped with a safety shut-off.

NOTE

If the engine is equipped with a hydraulic servo mechanism, it will be necessary to remove the tube from the top cover of the governor to the fuel pump and governor drive housing.

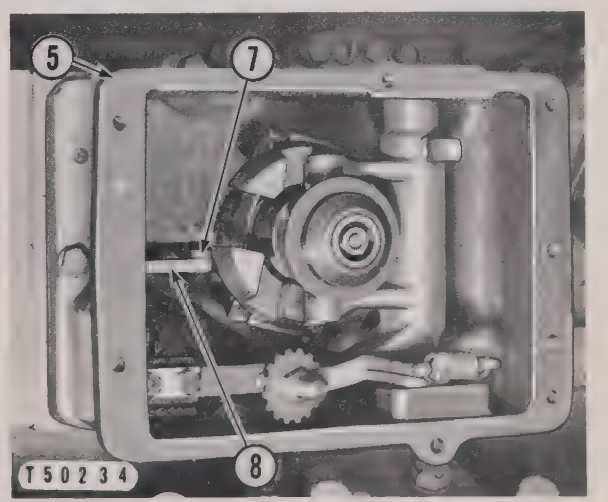


PREPARING TO REMOVE GOVERNOR
1–Oil line. 2–Oil manifold. 3–Governor upper housing. 4–Oil pressure gauge line. 5–Governor lower housing. 6–Governor control rod.

1. Remove upper housing **(3)** from lower housing **(5)** and disconnect the spring-loaded pin on lever assembly **(7)** from rack linkage **(8)**.

CAUTION

Check to see if the engine is equipped with a rack stop. See the topic, FUEL PUMP AND GOVERNOR DRIVE. If there is no rack stop, make certain that the rack does not move to the rear far enough to disengage from the fuel injection pumps. If the rack becomes disengaged, each pump must be retimed with the fuel rack.

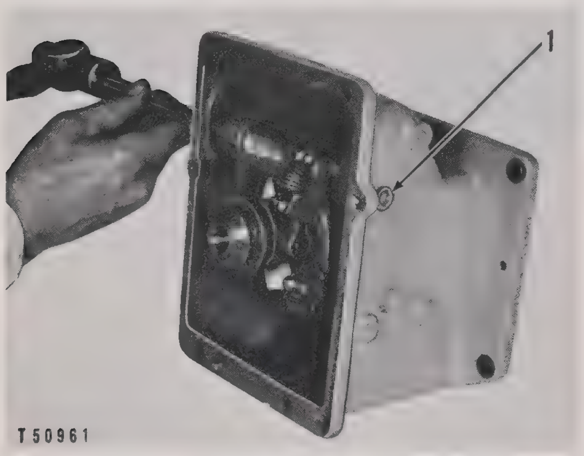


PREPARING TO REMOVE GOVERNOR
5–Lower housing. 7–Lever assembly. 8–Rack linkage.

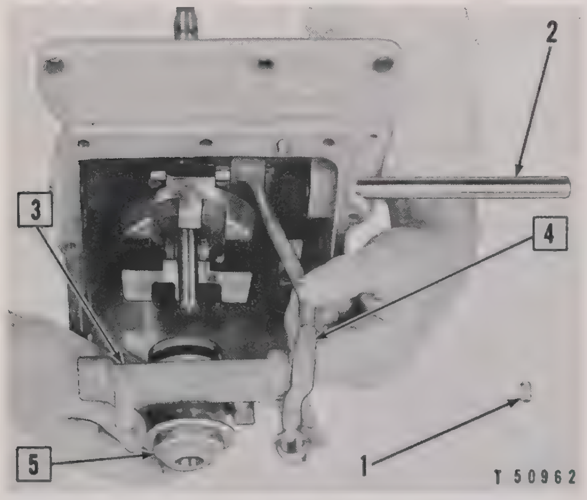
2. Remove the remaining mounting bolts and lift lower housing **(5)** upward and off the engine carefully so as not to damage the fuel pump and governor drive shaft or the governor drive pinion.

3. Replace all damaged gaskets. See the topic, GOVERNOR SEALS, for sealing the mounting bolt when installing the governor.

DISASSEMBLY AND ASSEMBLY



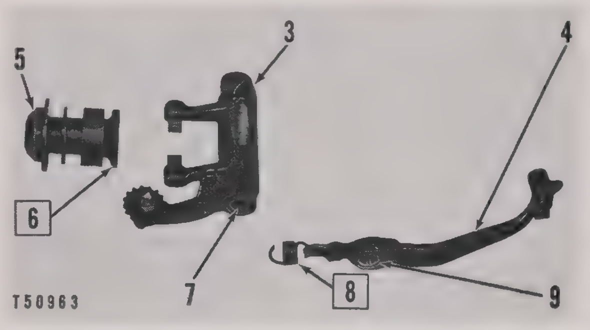
PREPARING TO REMOVE LEVER ASSEMBLIES
1–Plug.



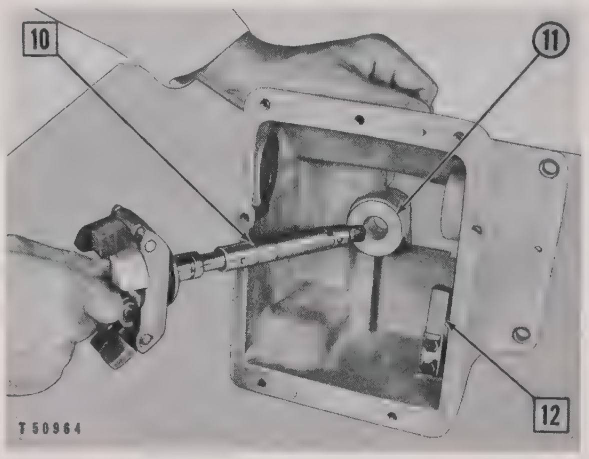
REMOVING CAGE ASSEMBLY AND LEVER ASSEMBLIES
1–Plug. 2–Shaft. 3–Lever assembly. 4–Lever assembly. 5–Cage assembly.

Drive lever assembly shaft **(2)** and plug **(1)** out of the governor housing.

Inspect cage assembly **(5)**, sleeve assembly **(6)** and bearings **(7)**, **(9)** and **(11)**.



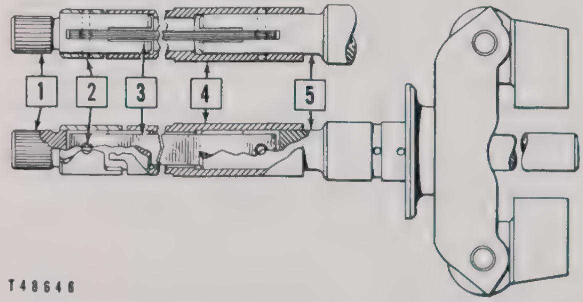
CAGE ASSEMBLY AND LEVER ASSEMBLIES
3–Lever assembly. 4–Lever assembly. 5–Cage assembly. 6–Sleeve assembly. 7–Bearings (two). 8–Spring. 9–Bearing.



SPINDLE ASSEMBLY REMOVAL
10–Spindle assembly. 11–Bearing. 12–Torque bar.

Spindle

1. Drive dowels **(2)** out of spindle assembly **(5)**. Remove sleeve **(4)**, shaft **(1)** and springs **(3)**.



REMOVING SHAFT AND SPRINGS FROM SPINDLE
1–Shaft. 2–Dowel. 3–Springs. 4–Sleeve. 5–Spindle assembly.

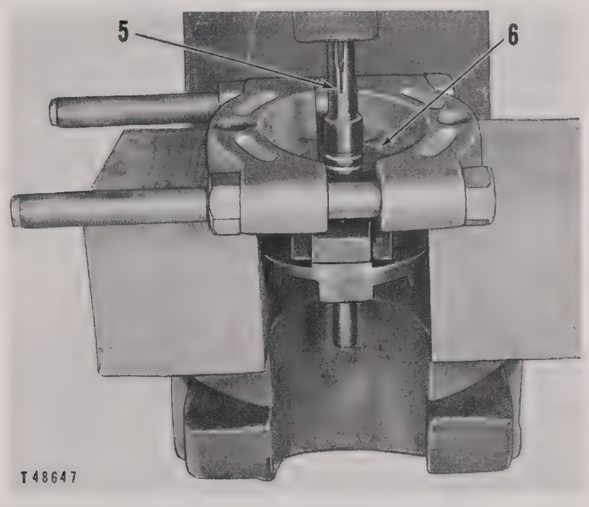
NOTE

When assembling the springs to the spindle and shaft, stake both dowels into position in two places on each end.

2. Press washer **(6)** from spindle **(5)** using the 8H663 Bearing Pulling Attachment.

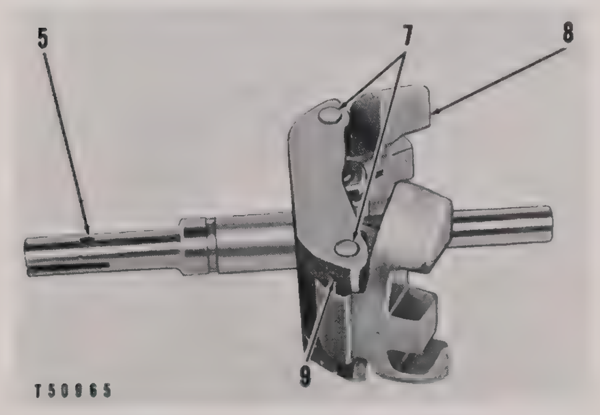
NOTE

A pin in the spindle fits into a groove on the inner diameter of the washer to prevent the washer from turning on the spindle. When installing a new washer, be sure the pin and groove are properly aligned.



PRESSING WASHER FROM SHAFT
5–Spindle. 6–Washer.

3. Press out pins **(7)** and remove weights **(8)**.
4. Replace the bearings (in the weights) if they are worn or damaged.
5. Place the weights into position and press the pins into place.



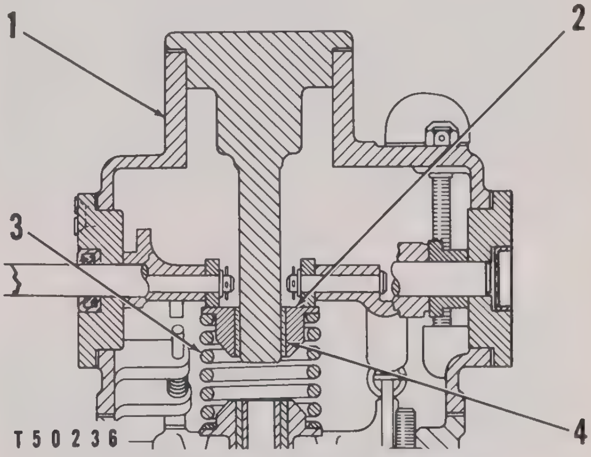
PREPARING TO DISASSEMBLE SPINDLE
5–Spindle. 7–Pins. 8–Weight. 9–Hole.

6. Use a small diameter punch through holes **(9)** to stake metal [which remains at the bottom of the holes] into the grooves in pins **(7)**.

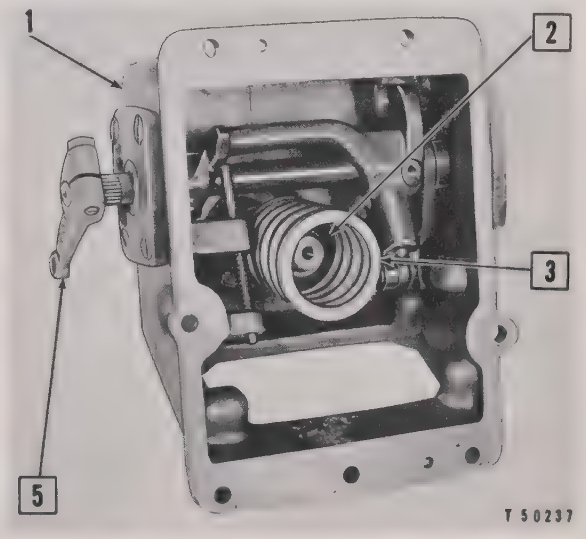
NOTE

If the metal shears from the bottom of holes **(9)** when removing the pins, drill new 3/32″ diameter holes to depth sufficient to leave 1/16″ of metal between the bottom of the holes and the pin bore for staking into the pin grooves.

Upper Housing (Mechanical)

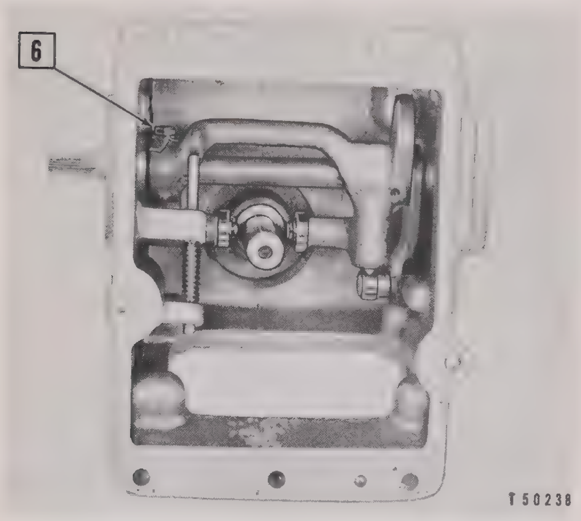


UPPER HOUSING — CROSS SECTION
1–Upper housing. 2–Retainer. 3–Spring. 4–Bearing.

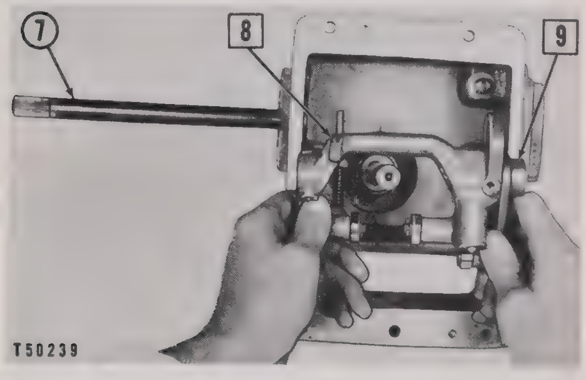


PREPARING TO DISASSEMBLE UPPER HOUSING
1–Upper housing. 2–Retainer. 3–Spring. 5–Control lever.

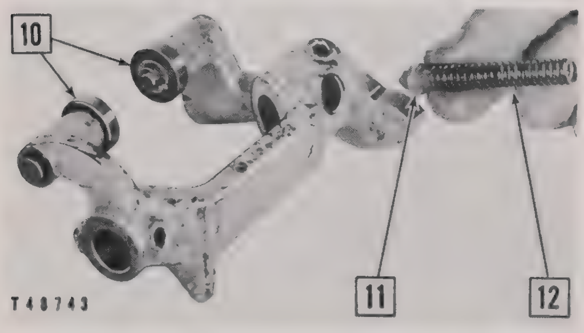
1. Replace bearing **(4)** in retainer **(2)**, if worn or damaged.
2. Slowly remove shaft **(7)** to prevent spring **(12)** from flying out of the lever assembly, since the shaft retains the spring and plunger **(11)** in the lever assembly.



PREPARING TO REMOVE LEVER ASSEMBLIES
6–Bolt and lock.

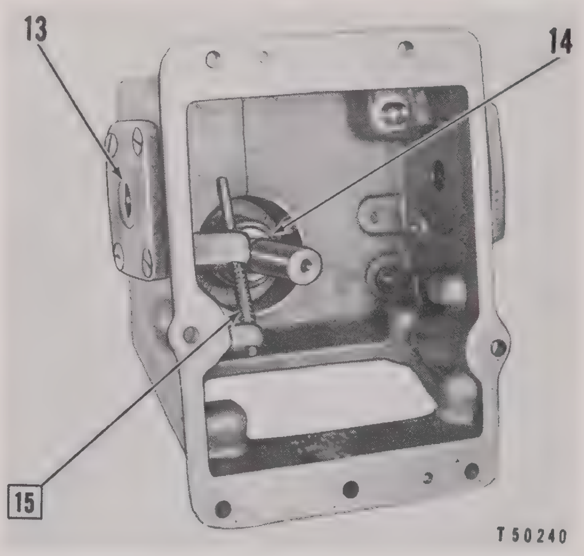


REMOVING LEVER ASSEMBLIES
7–Shaft. 8–Lever assembly. 9–Lever assembly.

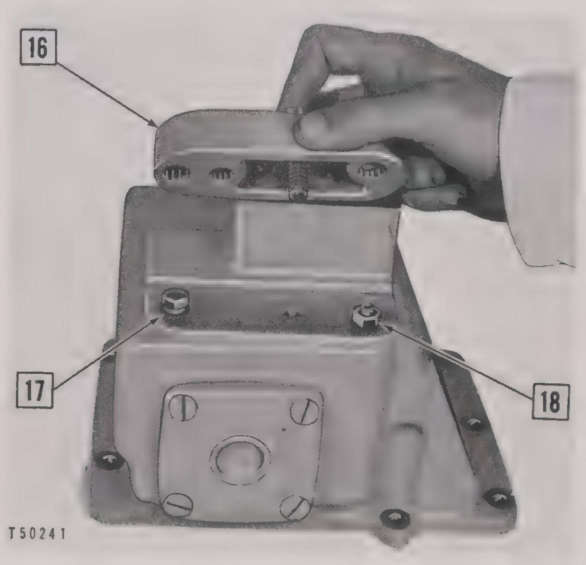


DISASSEMBLY OF LEVER ASSEMBLY
10–Cotter pins, washers and rollers. 11–Plunger. 12–Spring.

3. Break the wire seal and remove the bolts which secure cover **(14)** to the housing and remove the cover.
4. Replace seal **(13)** if damaged. Install the seal with the lip facing the inside of the housing.



UPPER HOUSING DISASSEMBLY
13–Seal. 14–Cover. 15–Snap ring, spring and pin.



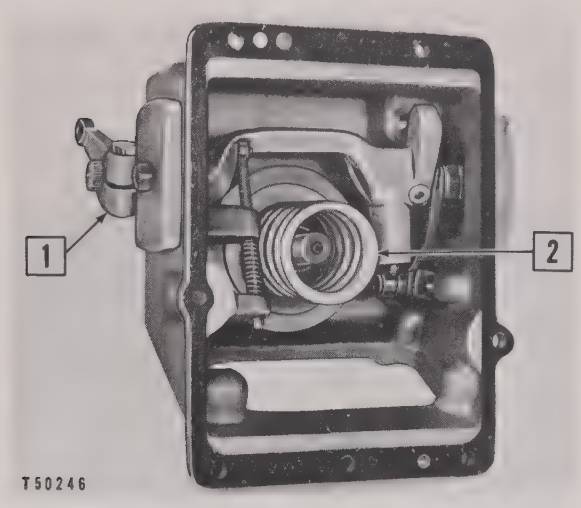
UPPER HOUSING DISASSEMBLY
16–Cover. 17–High idle adjusting screw.
18–Low idle adjusting screw.

NOTE

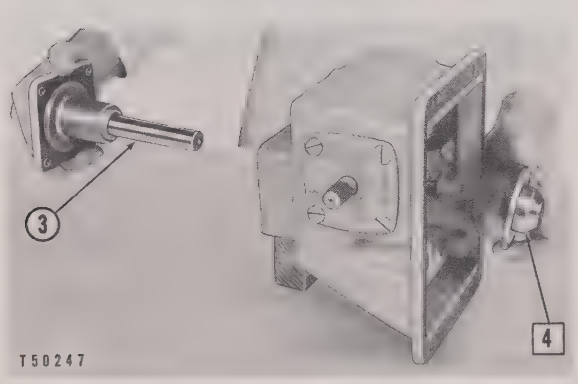
The guide on the low idle adjusting screw is removed from inside the housing while removing the adjusting screw.

Upper Housing (Hydraulic Servo Mechanism)

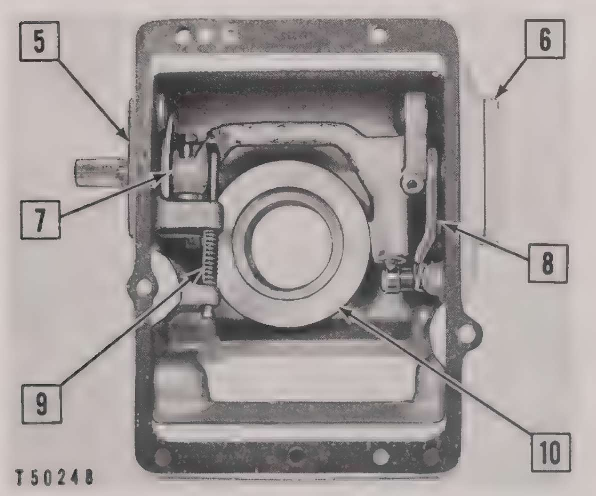
1. Break the wire seal and remove the bolts which secure cover **(3)** to the housing. Remove the cover. Replace if damaged or worn.
2. Replace the bearing in spring retainer **(4)** if necessary.



PREPARING TO DISASSEMBLE UPPER HOUSING
1–Lever. 2–Spring.



PREPARING TO DISASSEMBLE UPPER HOUSING
3–Cover. 4–Spring retainer.

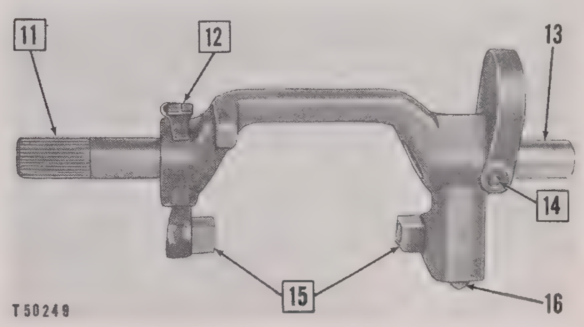


REMOVAL OF LEVER ASSEMBLIES
5–Cover. 6–Cover. 7–Lever assembly. 8–Lever assembly. 9–Snap ring, spring and pin. 10–Piston.

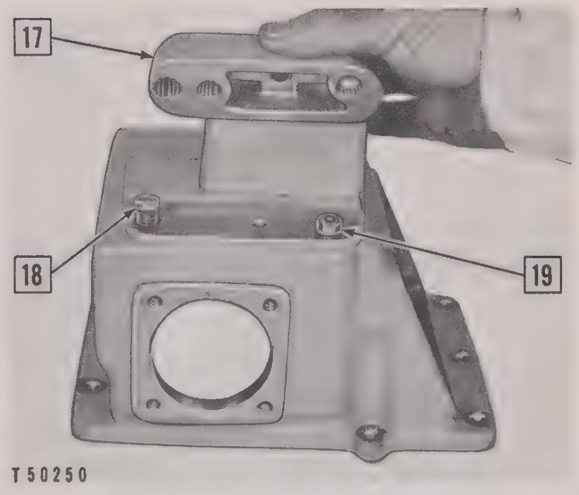
3. Slowly remove shaft **(13)** to prevent the spring behind plunger **(16)** from flying out, since the shaft retains the spring and plunger in the lever assembly.

NOTE

The guide on the low idle adjusting screw is removed from inside the housing while removing the adjusting screw.



DISASSEMBLY OF LEVER ASSEMBLY
11–Shaft. 12–Bolt and lock. 13–Shaft. 14–Bolt and lock. 15–Blocks. 16–Plunger.



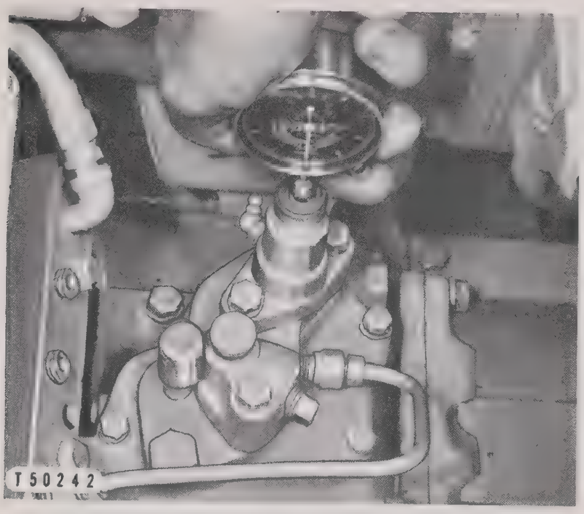
UPPER HOUSING DISASSEMBLY
17–Cover. 18–High idle adjusting screw. 19–Low idle adjusting screw.

4. Replace the seal in cover **(5)** if damaged. Install the seal with the lip facing the inside of the housing.
5. Replace all damaged gaskets.

ADJUSTMENTS

High and Low Idle Speeds

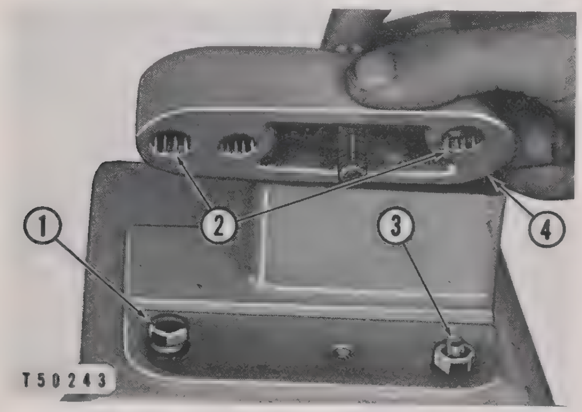
The engine idle speed can be checked at the tachometer drive housing, located on the fuel pump and governor drive housing or on the safety shut-off housing, if the engine is so equipped. Remove the cap and insert a hand tachometer as shown. The reading observed will be one-half engine speed.



CHECKING ENGINE IDLE SPEED

Remove cover **(4)** from the top of the governor and adjust the high and low idle speeds.

To increase the high and low idle speeds turn the adjusting screws **(1)** and **(3)** counterclockwise. Screw **(1)**, which is nearest the front of the governor, adjusts the high idle speed and screw **(3)** adjusts the low idle speed. Holes **(2)** in cover **(4)**, are serrated. The cover prevents the screws from turning after the cover is installed.



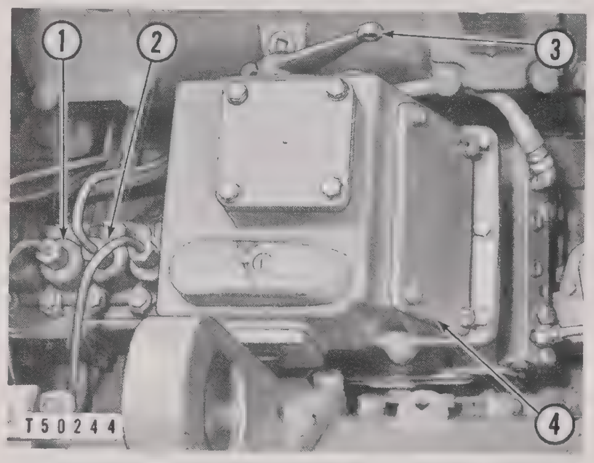
GOVERNOR ADJUSTMENTS
1–Screw. 2–Retainer holes. 3–Screw. 4–Cover.

After setting the idle speed, move the governor control lever and change the engine speed. Return it to the desired idle position and recheck the idle speed. Repeat this procedure and if necessary readjust the idle speeds until the desired idle speeds are obtained.

Fuel Rack Setting (Using 3H1690 Fuel Rack Setting Gauge)

The fuel rack setting can be checked and adjusted with the fuel injection pump housing either removed or installed on the engine.

1. Remove fuel injection pump **(2)**.
2. Break the wire seal and remove cover **(4)**, exposing adjusting screw **(8)**.



PREPARING TO CHECK FUEL RACK SETTING
1–Fuel injection pump. 2–Fuel injection pump. 3–Governor control lever. 4–Cover.

3. Install rack setting gauge **(5)** on the fuel injection pump housing in the same manner as installing a fuel injection pump.

NOTE

Place the gauge on the dowels with the marked tooth on the gauge aligned with the marked tooth on the fuel rack. Tooth marks are visible through the openings in the gauge dial and body. If the marks are not visible, remove fuel injection pump **(1)**, and the marks can then be seen through the opening in the fuel injection pump housing.

4. Move governor control lever **(3)** to the full load position and read the rack setting on gauge **(5)**.

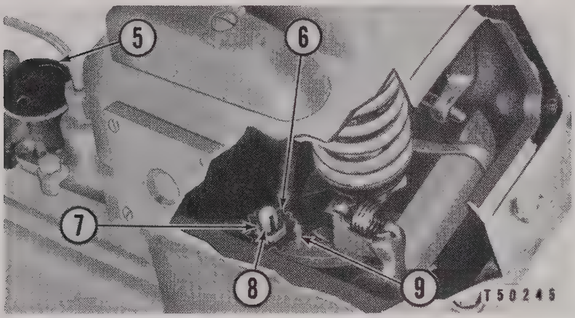
NOTE

See the applicable rack setting chart for correct settings.

5. If it is necessary to adjust the rack, loosen locknut **(7)**, raise lock **(6)** off lock pin **(9)** and turn adjusting screw **(8)** clockwise to decrease the rack setting, or counterclockwise to increase the rack setting. The adjusting screw must touch the torque bar.

NOTE

If a torque spring and spacers are used, place a thickness gauge the same thickness as the spacer under the torque spring. This will prevent deflection of the spring and an inaccurate reading. See the proper rack setting chart for the correct spacer thickness.

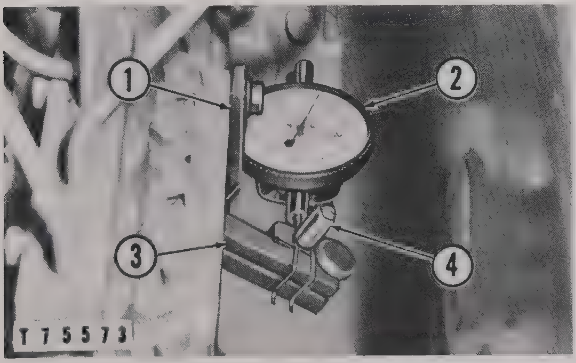


SETTING THE FUEL RACK
5–3H1690 Fuel Rack Setting Gauge. 6–Lock. 7–Locknut. 8–Adjusting screw. 9–Lock pin.

6. When adjusted properly, position the lock with its nearest matching groove over the lock pin and tighten the locknut.
7. Remove rack setting gauge **(5)** and install the removed parts in the reverse order of removal. See the topic, GOVERNOR SEALS, for sealing the cover.

Fuel Rack Setting (Using 9M9267 Rack Position Indicator Tool Group)

1. Move the governor control lever to the shut-off position.
2. Break the wire seal and remove the governor cover to expose the fuel rack adjusting screw. Remove the side cover from the fuel injection pump housing.
3. Install dial indicator **(2)** on adapter assembly **(1)**. Use a side cover bolt to install the adapter and indicator on the fuel injection pump housing.



PREPARING TO SET THE FUEL RACK
1–9M9354 Adapter Assembly. 2–9M9268 Dial Indicator. 3–9M9357 Angle Clamp Assembly. 4–3S3975 Spacer.

4. Loosely install angle clamp assembly **(3)** on the fuel rack and attach spacer **(4)** to the angle clamp.
5. Slide the angle clamp and spacer against the spindle of dial indicator **(2)** to get a reading on the indicator, then tighten the angle clamp on the rack.
6. Move the dial of indicator **(2)** to zero and remove spacer **(4)**.
7. Move governor control lever to full load position and read rack setting on dial indicator **(2)**.

NOTE

See the applicable rack setting chart for correct settings.

8. If it is necessary to adjust the rack, see Steps 5 and 6 in the topic, FUEL RACK SETTING (Using 3H1690 Fuel Rack Setting Gauge).

NOTE

If it is desirable to operate the engine to read the rack setting on dial indicator **(2)**, make certain the fuel rack move freely throughout its entire length of travel before starting the engine.

9. Remove the tool group and install the covers. See the topic, GOVERNOR SEALS, for sealing the governor cover.

Hydraulic Isochronous Governor

For electric sets using a hydraulic type governor, further service instructions are available from the Service Department, Peoria, Illinois.

The governor is located in the V at the flywheel end of the engine and is mounted on the fuel pump and governor drive housing. It is driven by a gear on the fuel injection pump and governor drive shaft.

GOVERNOR SEALS

The fuel rack adjusting screw cover and one of the governor adapter assembly mounting bolts are sealed with a wire and aluminum seal. To adjust the fuel rack setting, the seal must be removed.

Rack settings are carefully set at the factory and should not be changed without specific instructions. An incorrectly adjusted fuel rack affects the operation of the turbocharger. See the topic, TURBOCHARGER ALTITUDE OPERATION.

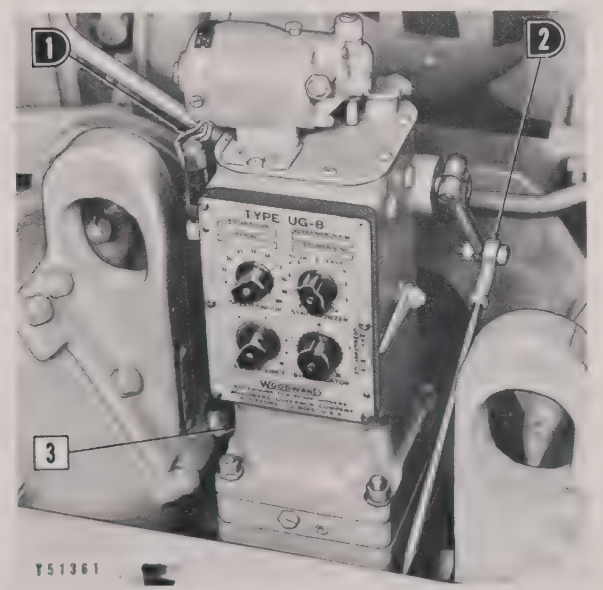
NOTE

Factory installed seals are identified by the letters CT CO. Dealer's 6H4160 Sealing Tool Assembly will impress the letters DLR on the seals.

REMOVAL AND INSTALLATION

NOTE

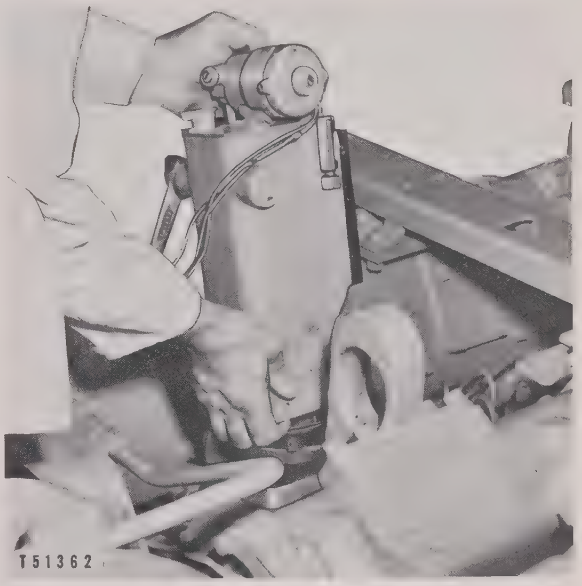
Mark the motor leads and the control panel leads to prevent reversing the motor rotation upon installation of the governor.



PREPARING TO REMOVE GOVERNOR

☐ Remove ● Disconnect

1–Motor leads. 2–Carburetor control linkage. 3–Governor.



REMOVING GOVERNOR

CAUTION

Do not drop or rest the governor on its drive shaft.

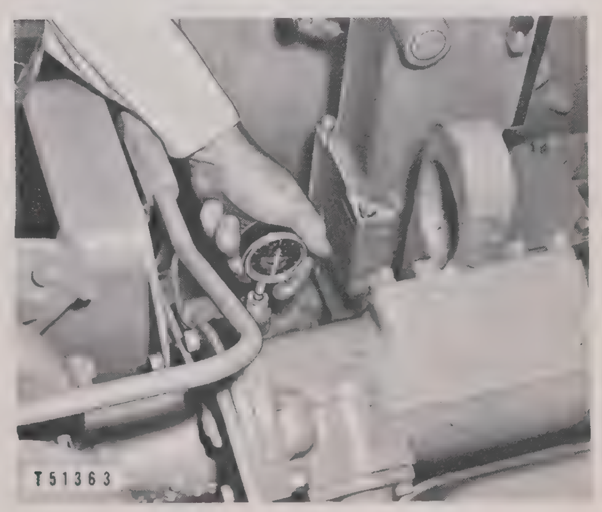
NOTE

When the governor is installed, particular care should be exercised to see that it is mounted squarely. The splined drive shaft should drop into place by its own weight.

ADJUSTMENTS

High and Low Idle Speed

The engine idle speed can be checked at the tachometer drive connection. Remove the connection

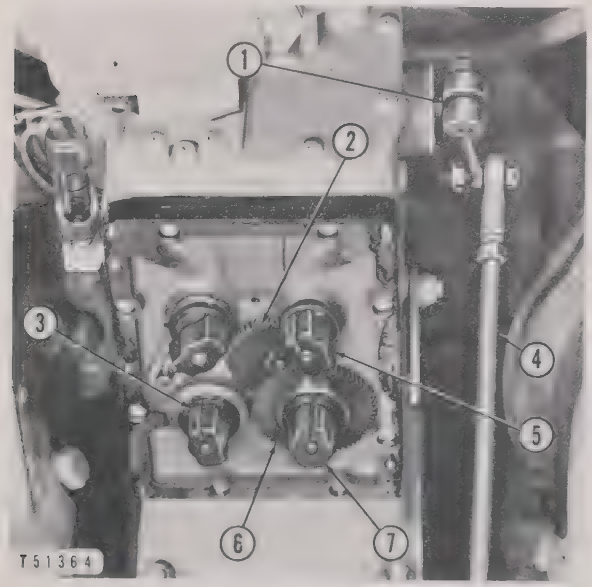


CHECKING ENGINE IDLE SPEED

or cover from the tachometer drive and insert a hand tachometer as shown. The reading observed will be one-half engine speed.

Only the high idle speed can be adjusted as the engine usually shuts off before the stop on gear **(6)** contacts idler gear **(2)** on the right side.

1. Set the load limit control knob **(3)** at 5 to prevent the engine from getting excessive fuel and from accelerating too rapidly.
2. As further precaution against the engine accelerating too rapidly, remove the nut and cotter pin from the bolt that secures the linkage **(4)** to the terminal shaft lever **(1)**. In the case of overspeeding, the bolt can be easily removed and the fuel rack can be controlled manually.
3. Start the engine and gradually increase the amount of fuel. When the engine has reached operating temperature, install the nut and cotter pin and turn the load limit control from 5 to 10. By means of the synchronizer, adjust the engine to the required speed and check the high idle stop.
4. If the high idle stop does not prevent further governor synchronizer movement at the required speed, adjustment is necessary. Remove the dial plate.



GOVERNOR ADJUSTMENTS
1–Terminal lever. 2–Idler gear. 3–Load limit control. 4–Linkage. 5–Synchronizer control knob. 6–Gear. 7–Synchronizer indicator knob.

5. Loosen the setscrew on the synchronizer indicator knob **(7)**, drive out the tapered pin if so fitted, and remove the knob.
6. Pull the gear **(6)** out of mesh with the gear **(2)**.
7. When setting the high idle speed, turn the synchronizer control knob **(5)** clockwise until the desired high idle speed is reached.
8. Set the high idle speed stop by turning the gear **(6)** clockwise until the gear pin contacts the idler gear **(2)**. Mesh the gears.
9. After setting the idle speed stop, turn the synchronizer control knob to change the engine speed. Return it to the desired position and recheck the idle speed. Reset if necessary.

The synchronizer indicator pointer disc may be reset, if necessary. With the engine running at high idle, stop the engine by turning the load limit control **(3)** to zero. Pry off the synchronizer indicator pointer disc and reinstall at an indication such as 12 to indicate high idle.

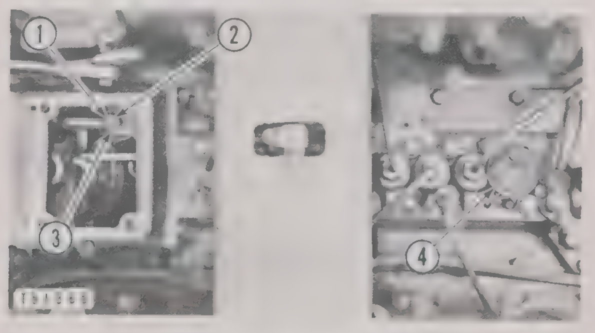
10. Install the synchronizer indicator knob and the dial plate.

Fuel Rack Setting

1. Break the seal and remove the fuel rack adjusting screw cover located in front of the governor on the governor drive housing.
2. Remove the front fuel injection pump.
3. Install the 3H1690 Fuel Rack Setting Gauge **(4)** on the fuel injection pump housing in the same manner as installing a fuel injection pump.

NOTE

Place the gauge on the dowels with the marked tooth on the gauge aligned with the marked tooth on the fuel rack. Tooth marks are visible through the openings in the gauge dial and body. If the marks are not visible, remove the next fuel injection pump, the marks can then be seen through the opening in the fuel injection pump housing.



SETTING THE FUEL RACK
1–Adjusting screw. 2–Adjusting screw locknut. 3–Lock. 4–3H1690 Fuel Rack Setting Gauge.

4. Set the governor load limit control knob on 10. Using the lever on the governor terminal shaft, move the fuel rack from the fuel off position toward the full on position until contact is made with the adjusting screw **(1)**, and read the Rack Setting Gauge **(4)**.

CAUTION

Do not force the engine linkage to increase fuel without first turning the load limit knob to 10.

5. Loosen the adjusting screw locknut **(2)** and raise the lock **(3)** so the adjusting screw can be turned freely.
6. Turn the adjusting screw counterclockwise to increase the fuel rack travel or clockwise to decrease the rack travel. When the fuel rack is properly adjusted, lower the lock into the nearest matching notch and tighten the locknut.

NOTE

The construction of the governor allows movement of the fuel rack toward the full on position with relatively little effort. However, rack movement toward the fuel off position must be done slowly and requires more effort as oil must be forced out from behind a piston in the governor.

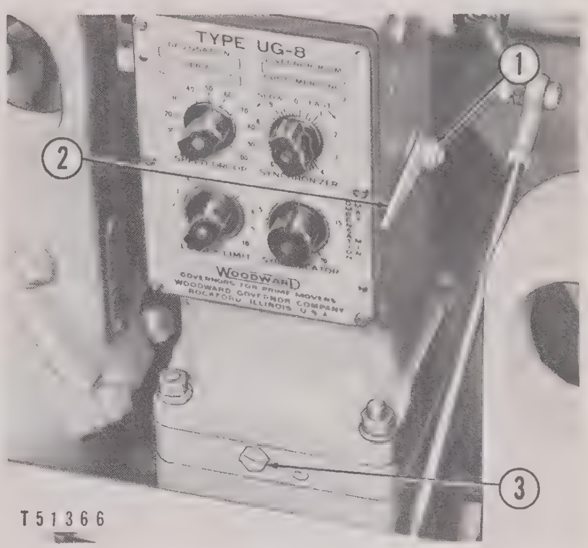
7. Install the adjusting screw cover and the fuel injection pump.

Compensating Adjustment

Although the governor may appear to be operating satisfactorily at no load, high overspeeds and underspeeds after load changes and slow return to normal speed are the results of incorrect compensation adjustments.

Compensating adjustments should be made after the temperature of the engine and the oil in the governor have reached normal operating values and with the engine running at no load conditions.

1. Loosen the nut **(1)** and set the compensation adjusting pointer **(2)** at MAX.
2. Remove the plug **(3)** and, using the shallow slots, open the compensating needle valve three or more turns.
3. Allow the engine to surge violently for about 1 - ½ minutes to bleed trapped air from the governor oil passages.
4. Lower the pointer to two points above MIN.



COMPENSATING ADJUSTMENT
1–Nut. 2–Compensating adjusting pointer. 3–Plug.

5. Gradually turn the needle valve in a clockwise direction until the engine just stops surging. From this position, continue to turn the needle valve noting the portion of turn required to bottom the valve. Return the needle valve to the position where the surging just stopped.
6. Test the engine at various speeds for surging. If no surging exists and the needle valve is approximately ½ to ¾ turn open, the compensating adjustment is satisfactory and the remaining steps can be excluded.

NOTE

Earlier model Woodward UG-8 Governors with the single spring compensating system will usually require a needle valve opening of from ⅛ to ¼ turns.

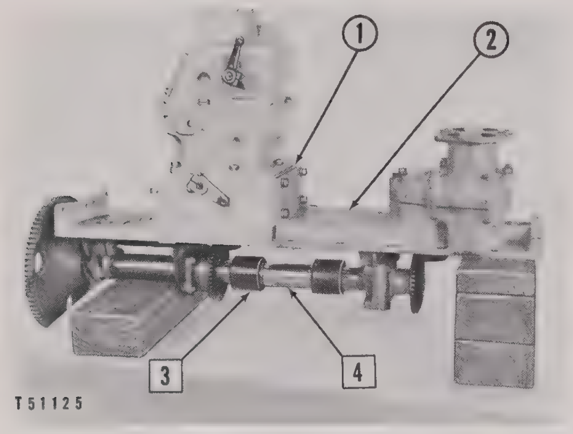
7. Raise the compensating adjusting pointer two divisions of the scale.
8. Open the needle valve approximately one turn and repeat steps 5 and 6.
9. Repeat steps 7, 8, 5 and 6 until a satisfactory compensating adjustment is reached. If the needle valve is less than ⅛ turn open, the return of the engine to normal speed after a load change will be slow. Raising the compensation adjusting pointer too far toward the maximum position will cause an excessive speed change when the load changes.

Governor

(Natural Gas Engines)

REMOVAL AND INSTALLATION

1. Remove the magneto and governor drive as described in the covering topic.

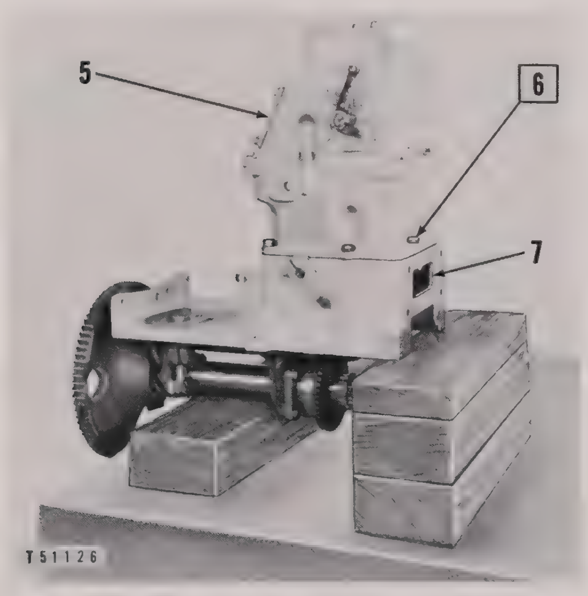


REMOVING MAGNETO DRIVE

☐ Remove

1–Governor drive housing. 2–Magneto drive housing. 3–Coupling. 4–Shaft.

2. Position the magneto and governor drive as shown and remove the magneto drive housing **(2)** from the governor drive housing **(1)**. See the topic, MAGNETO DRIVE.

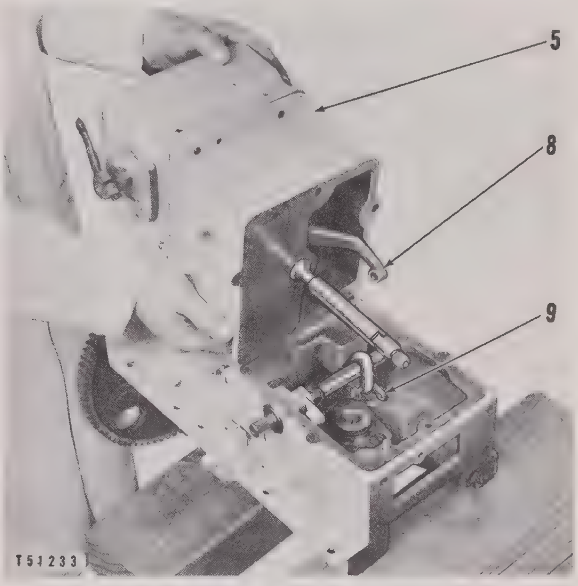


PREPARING TO REMOVE GOVERNOR

☐ Remove

5–Governor. 6–Bolts. 7–Opening.

3. Position the governor drive housing so that the opening **(7)** is accessible.
4. Working through the opening **(7)**, disconnect the lever **(8)** from the linkage **(9)**.
5. Lift the governor **(5)** off the governor drive housing.



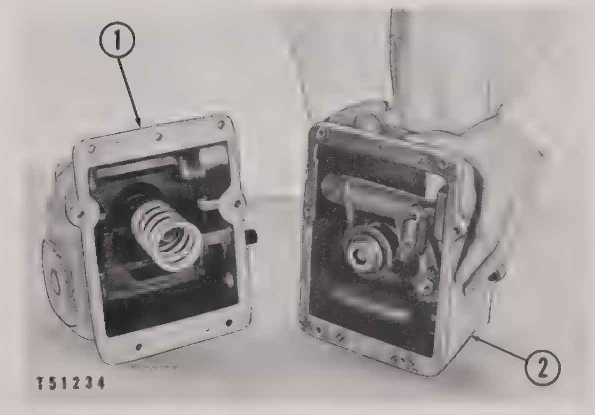
REMOVING GOVERNOR

5–Governor. 8–Lever. 9–Linkage.

6. Check all parts for damage or wear and install in reverse order of removal.

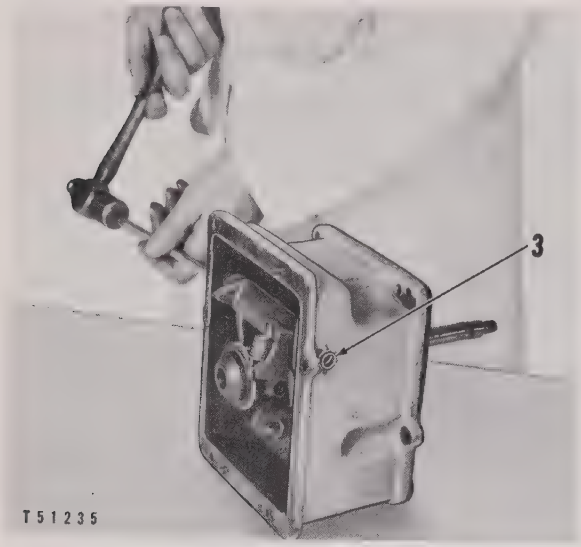
DISASSEMBLY AND ASSEMBLY

1. Remove the bolts which secure the upper governor housing **(1)** to the lower governor housing **(2)** and separate the housings.

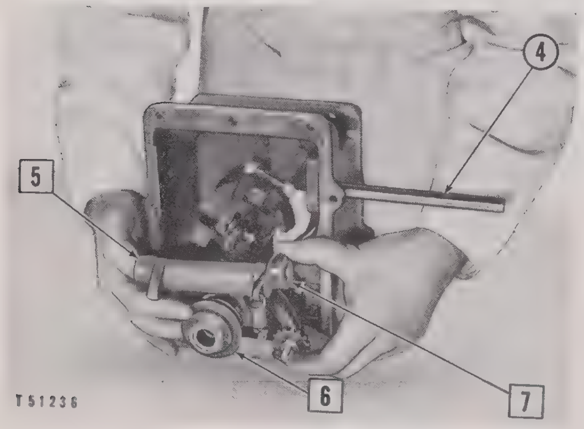


SEPARATING GOVERNOR HOUSINGS

1–Upper governor housing. 2–Lower governor housing.



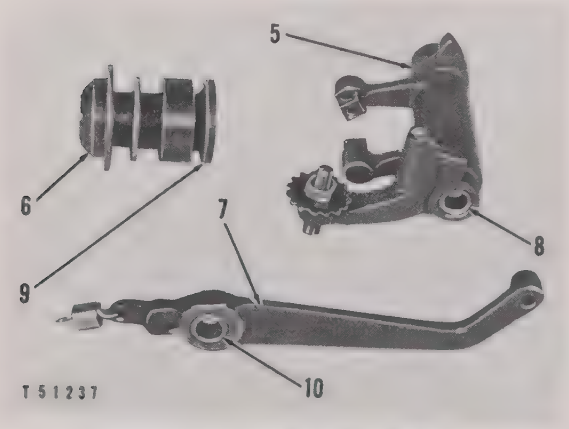
PREPARING TO REMOVE LEVER ASSEMBLIES
3–Plug.



REMOVING LEVER ASSEMBLIES

☐ **Remove**

4–Shaft. 5–Lever assembly. 6–Cage assembly. 7–Lever assembly.

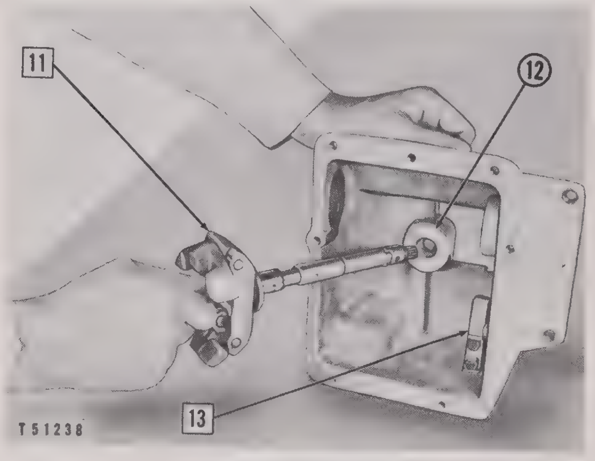


CAGE AND LEVER ASSEMBLIES
5–Lever assembly. 6–Cage assembly. 7–Lever assembly. 8–Bearing. 9–Sleeve assembly. 10–Bearing.

NOTE

Since the governor upper housing assembly **(1)** is the same as that used on the diesel engine, refer to the diesel engine governor topic for disassembly and assembly information.

2. Using a hammer and punch as shown, drive out the plug **(3)** and shaft **(4)**.
3. Inspect the sleeve assembly **(9)** and bearings **(8)** and **(10)** for damage and replace if necessary.



REMOVING SPINDLE

☐ **Remove**

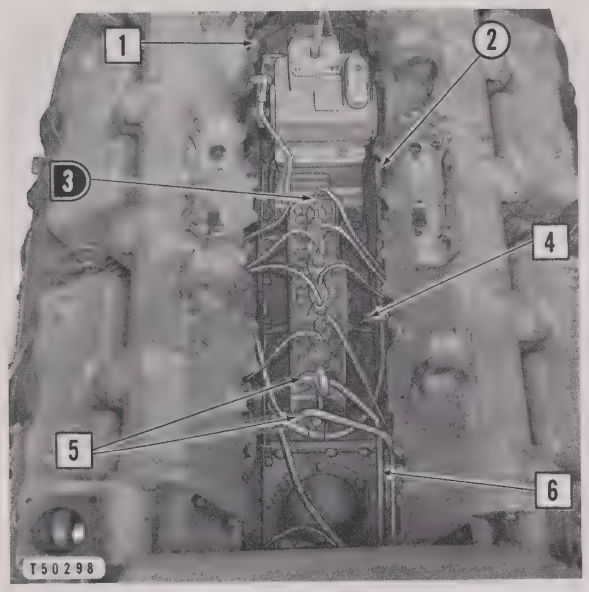
11–Spindle. 12–Bearing. 13–Torque bar.

4. Inspect the bearing **(12)** for wear or damage and replace if necessary.
5. Assemble in reverse order of disassembly.

Fuel Pump and Governor Drive

REMOVAL AND INSTALLATION

1. Drain the fuel from the fuel filter housing. Remove the air cleaner mounting bracket and governor control linkage.

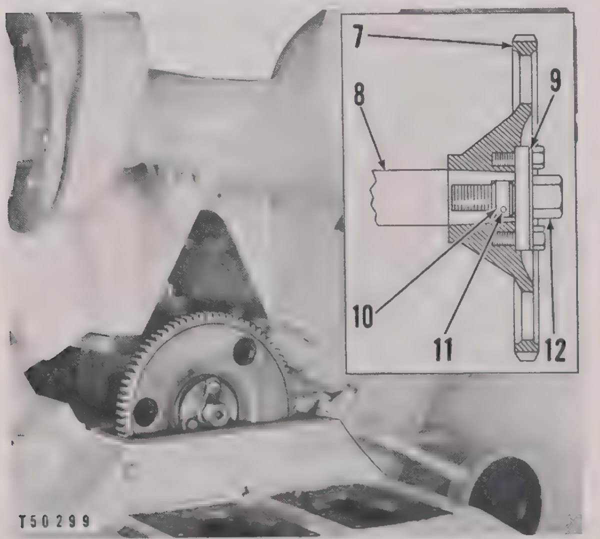


PREPARING TO REMOVE THE GOVERNOR AND FUEL INJECTION PUMPS

☐ **Remove** ◗ **Disconnect**

1–Cover. 2–Oil pressure gauge line. 3–Injection lines. 4–Bolts. 5–Fuel supply and return lines. 6–Cover.

2. Disconnect the oil pressure gauge line **(2)** at the governor. Lay this line aside to provide the necessary clearance.



FUEL INJECTION PUMP CAMSHAFT GEAR REMOVAL

7–Camshaft gear. 8–Shaft. 9–Plate. 10–Collar. 11–Taper pin. 12–Bolt.

NOTE

If the engine is equipped with a safety control shut-off, it may be easier to remove the control housing before removing the bolts **(4)** which secure the governor drive housing and the fuel injection pump housing to the block.

3. Attach a suitable hoist and raise the injection pump and governor drive housings so that the bolt **(12)** is accessible.

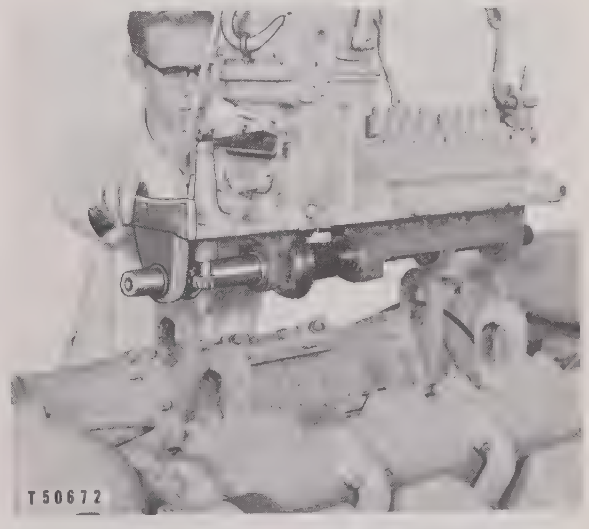
NOTE

A 5/16" - 18 (NC) eyebolt may be installed at the rear of the governor, as shown, to aid in removal of the unit.

NOTE

The aftercooler has been removed for illustration purposes only.

4. To remove the camshaft gear **(7)** from the shaft **(8)**, turn the bolt **(12)** counterclockwise. This forces the collar **(10)** against the plate **(9)** and pulls the gear from the shaft.
5. Lift the fuel injection pump and governor drive from the engine.



FUEL INJECTION PUMP AND GOVERNOR DRIVE REMOVAL

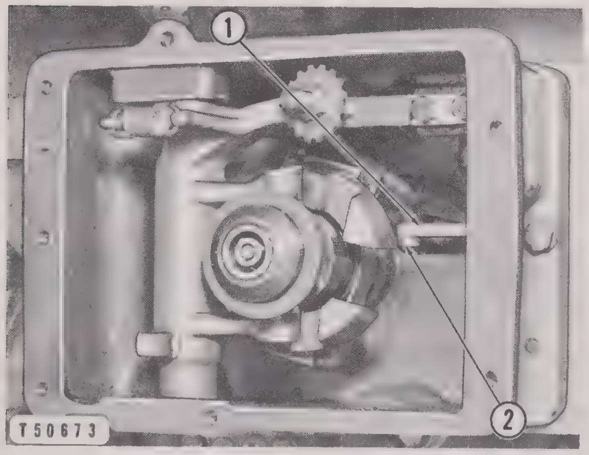
6. Remove the camshaft gear **(7)** from the engine.
7. Check all gaskets and seals for damage and replace if necessary.
8. Install in reverse order of removal.

NOTE

For the correct timing procedure, see the topic, TIMING THE FUEL INJECTION PUMP CAMSHAFT.

Fuel Injection Pump Removal and Installation

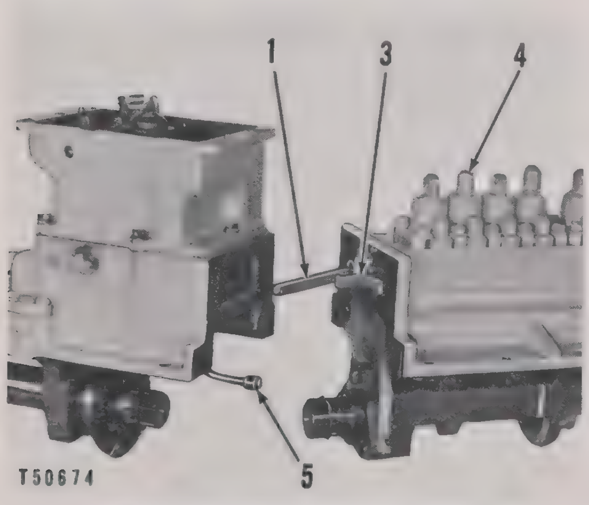
1. Remove the governor upper housing.
2. Using a screwdriver or other similar tool, pry the retainer on the lever assembly **(2)** away from the rack linkage **(1)** disconnecting the linkage.



PREPARING TO REMOVE FUEL INJECTION PUMPS
1–Rack linkage. 2–Lever assembly.

CAUTION

Before removing the fuel injection pump housing from the fuel pump and governor drive housing, check to see if there is a rack stop **(3)** installed on the fuel injection pump housing. If there is no rack stop or if the rack stop is the type which bolts to the governor drive pinion cage assembly, then extreme care should be taken when removing the fuel injection pump housing. If proper care is not taken, it is possible that the rack can be pulled too far out of the housing, thus allowing the rack to become disengaged from the fuel pump gear segments. Should this occur then each injection pump must be checked for proper engagement upon installation of the injection pump housing.



REMOVING FUEL INJECTION PUMPS
1–Rack linkage. 3–Rack stop. 4–Injection pump. 5–Oil tube.

3. As the housings are separated, the oil tube **(5)** will slip from its seat in the injection pump housing and the drive coupling can be slipped off the drive shaft.

CAUTION

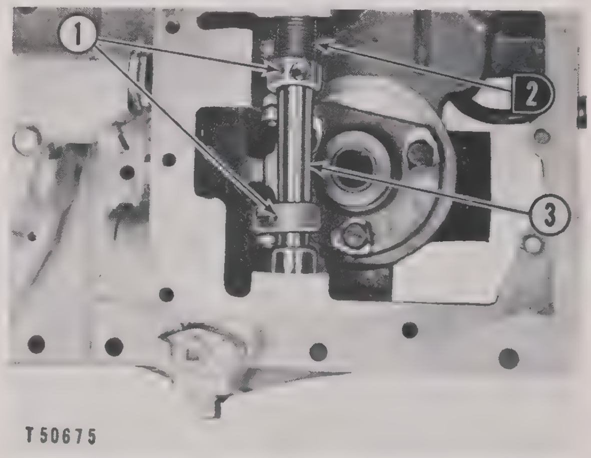
When assembling the injection pump housing to the governor drive housing, be sure the housings are aligned correctly so that the oil tube **(5)** will engage its seat in the injection pump housing.

4. Inspect all gaskets and seals, install the shaft coupling and install in reverse order of removal.

GOVERNOR

Governor Drive Disassembly and Assembly

1. Remove the governor lower housing from the governor and fuel injection pump drive housing.
2. Drive the spring pins **(1)** from the levers and shaft **(3)**.

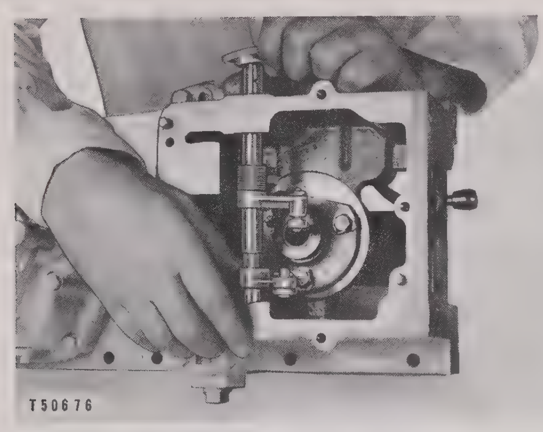


PREPARING TO REMOVE SAFETY SHUT-OFF SHAFT

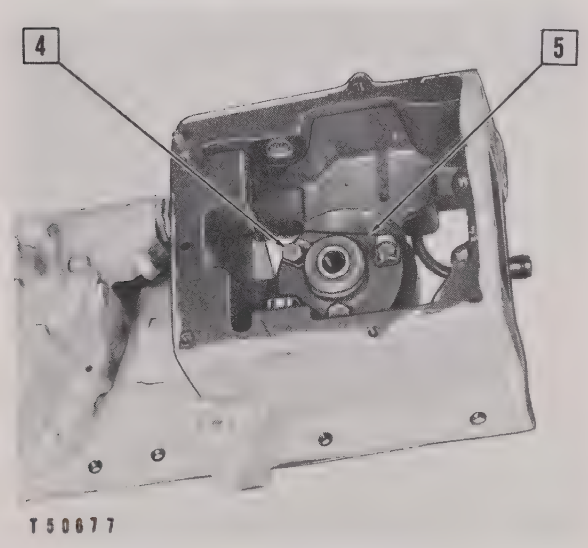
D Disconnect

1–Spring pins. 2–Spring. 3–Safety shut-off shaft.

3. Slide the safety shut-off shaft **(3)** out of the housing as shown.
4. Inspect the bearings at both sides of the housing for damage and replace if necessary.
5. For instructions on disassembly of the governor drive pinion cage, see the topic, GOVERNOR DRIVE PINION DISASSEMBLY AND ASSEMBLY.



REMOVING SAFETY SHUT-OFF SHAFT

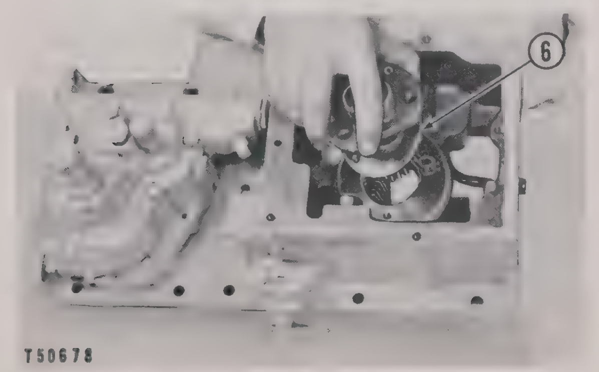


PREPARING TO REMOVE GOVERNOR DRIVE PINION ASSEMBLY

☐ **Remove**

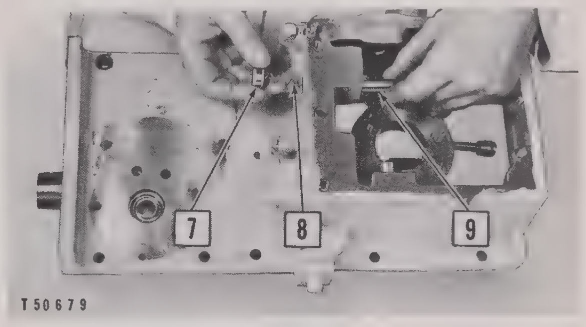
4–Bolts (three). 5–Pinion assembly.

6. At the time of installation, install enough shims between the pinion cage assembly and the housing to provide the correct tooth contact.



REMOVING GOVERNOR DRIVE PINION ASSEMBLY
6–Shims.

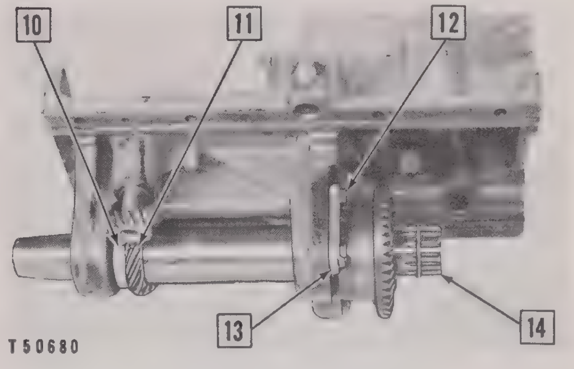
7. Remove the safety shut-off control housing, if so equipped.
8. Remove the snap ring which holds the retainer **(7)** on the shaft **(9)**.



REMOVING SAFETY SHUT-OFF PLUNGER

☐ **Remove**

7–Retainer. 8–Spring. 9–Plunger.



REMOVING DRIVE SHAFT

☐ **Remove**

10–Locknut. 11–Gear. 12–Bolts. 13–Thrust plate. 14–Drive shaft.

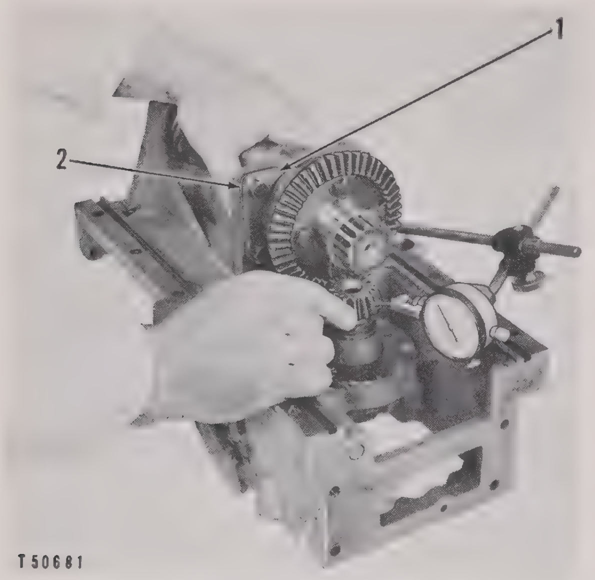
NOTE

For proper drive shaft adjustment, see the topic, ADJUSTMENT.

9. Inspect the parts for damage and wear and replace if necessary. Assemble in reverse order of disassembly installing the required number of shims between the gear **(11)** and the shaft **(14)** for proper alignment of the tachometer drive gears.

Adjustment

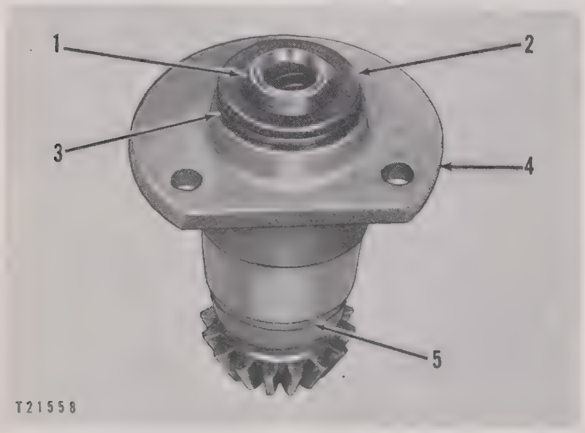
To adjust the backlash between the pinion and drive gear, set up a dial indicator similar to the method shown.



CHECKING BACKLASH
1–Thrust plate. 2–Shims.

Adjust the backlash to the value given in the topic, SPECIFICATIONS, by removing or replacing shims **(2)** behind the thrust plate **(1)**.

Governor Drive Pinion Disassembly and Assembly



REMOVING THE PINION AND BEARINGS
1–Pinion. 2–Washer. 3–Bearing. 4–Cage assembly. 5–Bearing.

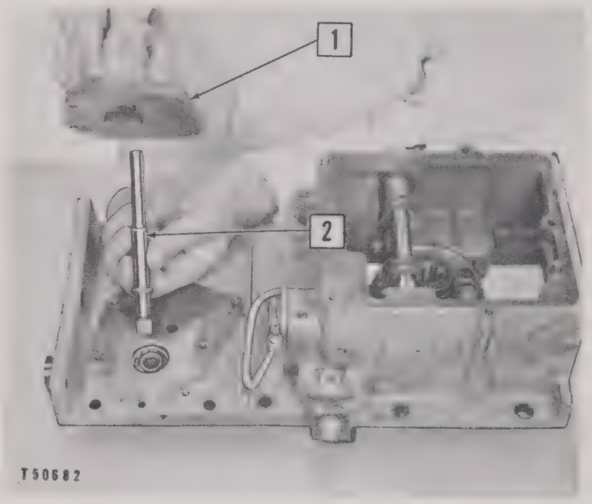
1. Using a suitable spacer, press the pinion **(1)** from the cage assembly **(4)** and remove the washer **(2)**.
2. Inspect the bearings **(3)** and **(5)** for damage and wear.
3. Install a new cage assembly if the bearings are unfit for further use.
4. Install the pinion and press the washer onto the pinion.

NOTE

With the washer pressed tight against the shoulder of the pinion, the cage assembly must have .002" - .006" end clearance.

TACHOMETER DRIVE

Removal and Installation



REMOVAL OF TACHOMETER DRIVE

☐ **Remove**

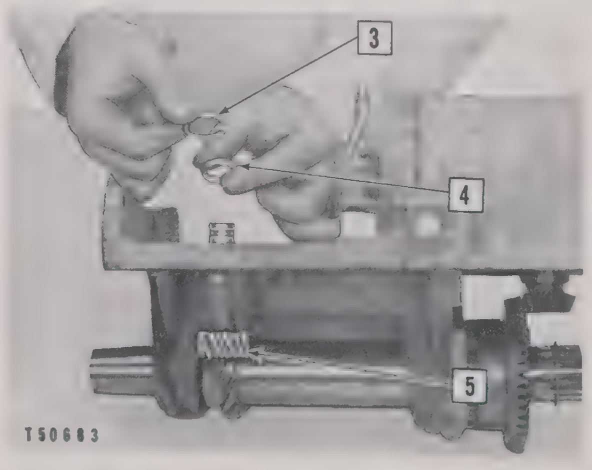
1–Cover. 2–Drive shaft.

Inspect the shaft **(2)** for wear or damage and replace if necessary.

Disassembly and Assembly

Push the gear **(5)** up to allow access to the retainer **(4)**.

Inspect the bearing and replace if necessary.



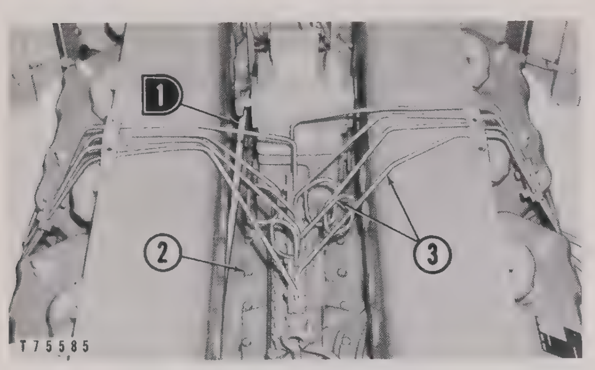
REMOVING TACHOMETER DRIVE GEAR

☐ **Remove**

3–Snap ring. 4–Retainer. 5–Drive gear.

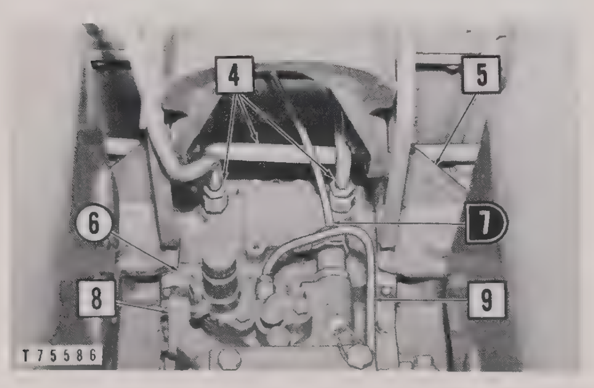
REMOVAL AND INSTALLATION

1. Drain the fuel from the fuel filter housing. Remove the governor control linkage.



PREPARING TO REMOVE THE GOVERNOR AND FUEL INJECTION PUMP HOUSING
1–Oil pressure gauge line. 2–Bolts. 3–Injection lines.

2. Remove the fuel supply and fuel bleed lines at the front of the fuel injection pump housing.
3. Remove all fuel injection lines **(3)**.
4. Remove bolts **(2)** that secure the governor and fuel injection pump housing to the engine.



PREPARING TO REMOVE SAFETY SHUT-OFF ASSEMBLY
4–Turbocharger oil lines. 5–Engine lifting bracket. 6–Cover. 7–Safety shut-off reset cable. 8–Safety shut-off assembly. 9–Oil line.

5. Remove cover **(6)** to allow the camshaft drive gear to remain on the drive shaft when the fuel injection pump housing and governor drive is removed from the engine.

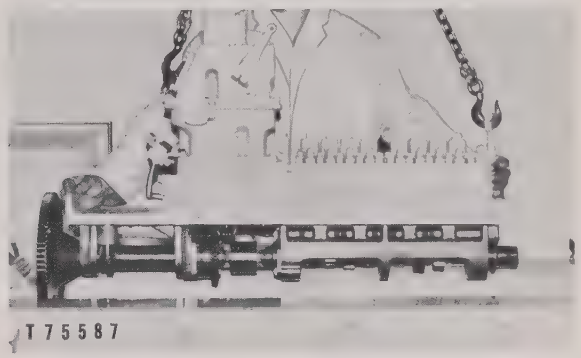
NOTE

A 5/16" - 18 NC forged eyebolt may be installed at the rear of the governor to aid in removal of the unit.

6. Use a hoist and remove the injection pump and governor drive housings. Approximate weight is 180 lbs.

NOTE

To remove the camshaft drive gear from the shaft, turn the retaining bolt counterclockwise. This forces a collar on the bolt against the plate on the gear hub pulling the gear from the shaft.



FUEL INJECTION PUMP HOUSING AND GOVERNOR DRIVE HOUSING REMOVAL

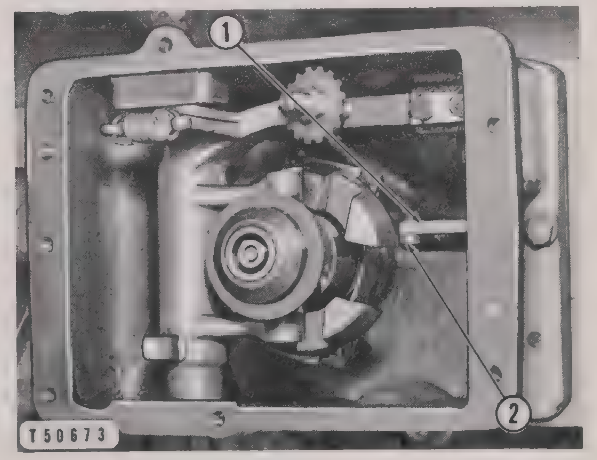
7. Replace gaskets and seals as necessary.
8. Install in reverse order of removal.

NOTE

For the correct timing procedure, see the topic TIMING THE FUEL INJECTION PUMP CAMSHAFT.

Fuel Injection Pump Removal and Installation

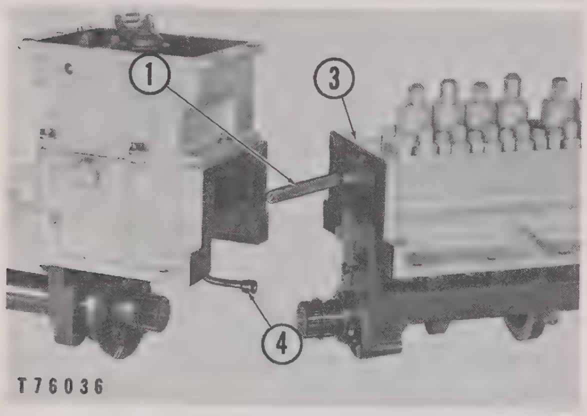
1. Remove the governor upper housing.
2. Use a screwdriver to pry the retainer on lever assembly **(2)** away from rack linkage **(1)** to disconnect the linkage.



PREPARING TO REMOVE FUEL INJECTION PUMPS
1–Rack linkage. 2–Lever assembly.

3. As the housings are separated, oil tube **(4)** will slip from its seat in injection pump housing **(3)**

and the drive coupling will slip off the drive shaft.



REMOVING FUEL INJECTION PUMP HOUSING
1–Rack linkage. 3–Injection pump housing. 4–Oil tube.

CAUTION

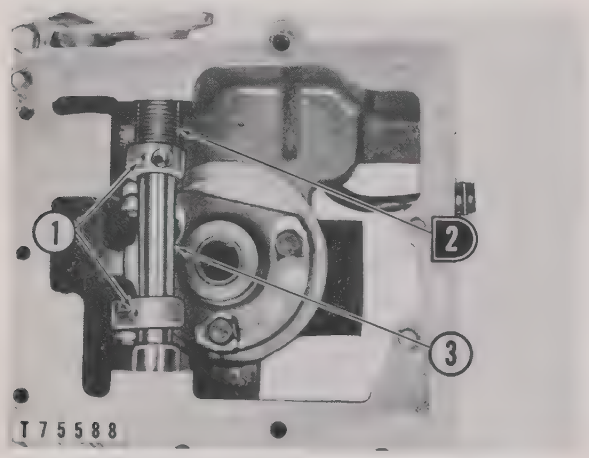
When assembling the injection pump housing to the governor drive housing, be sure the housings are aligned correctly so oil tube **(4)** will engage its seat in the injection pump housing.

4. Inspect all gaskets and seals. Install the shaft coupling in reverse order of removal.

GOVERNOR

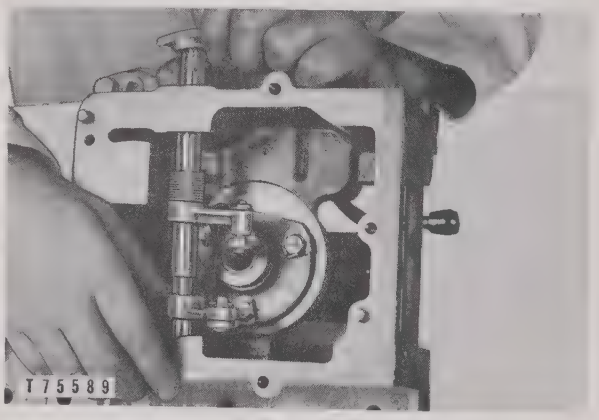
Governor Drive Disassembly and Assembly

1. Remove the governor lower housing from the governor and fuel injection pump drive housing.
2. Drive spring pins **(1)** from levers and shaft **(3)**.

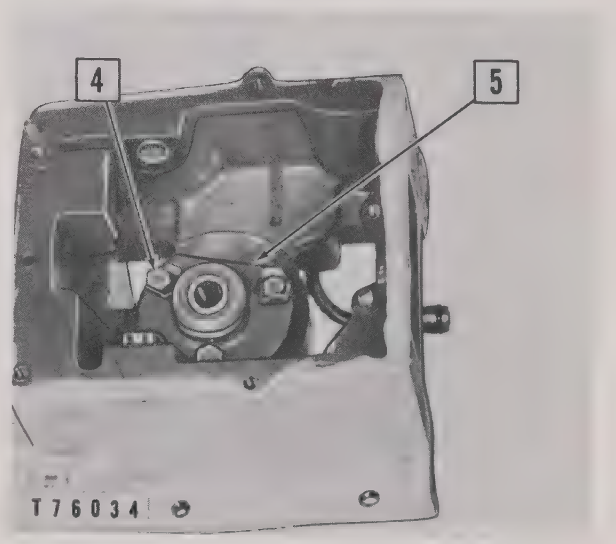


PREPARING TO REMOVE SAFETY SHUT-OFF SHAFT
1–Spring pins. 2–Spring. 3–Safety shut-off shaft.

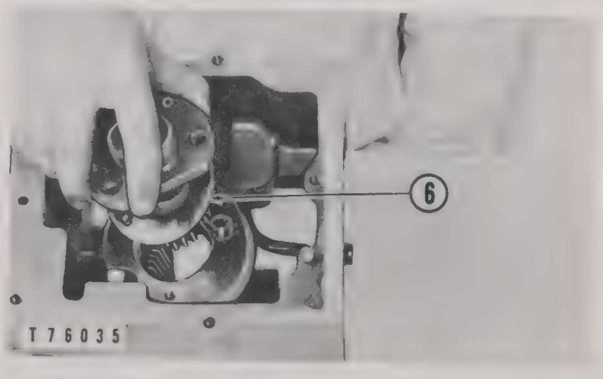
3. Slide safety shut-off shaft **(3)** out of the housing as shown.
4. Replace the bearings at both sides of the housing if damaged.
5. For instructions on disassembly of the governor drive pinion cage, see the topic GOVERNOR DRIVE PINION DISASSEMBLY AND ASSEMBLY.



REMOVING SAFETY SHUT-OFF SHAFT



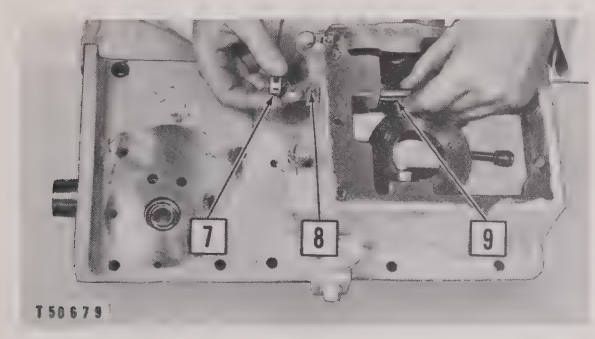
PREPARING TO REMOVE GOVERNOR DRIVE PINION ASSEMBLY
4–Bolts (three). 5–Pinion assembly.



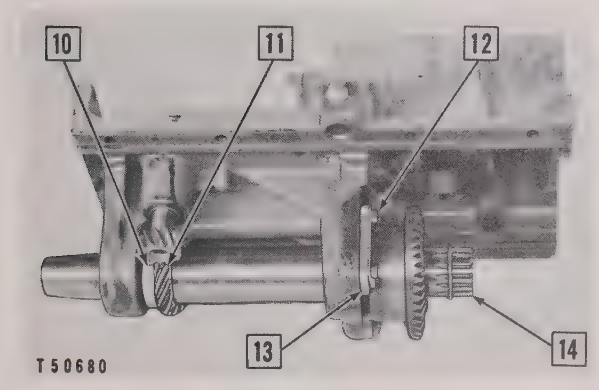
REMOVING GOVERNOR DRIVE PINION ASSEMBLY
6–Shims.

6. At the time of installation, install enough shims **(6)** between the pinion cage assembly and the housing to provide the correct tooth contact.

7. Remove the snap ring which holds retainer **(7)** on shaft **(9)**.



REMOVING SAFETY SHUT-OFF PLUNGER
7–Retainer. 8–Spring. 9–Plunger.



REMOVING DRIVE SHAFT
10–Locknut. 11–Gear. 12–Bolts. 13–Thrust plate. 14–Drive shaft.

NOTE

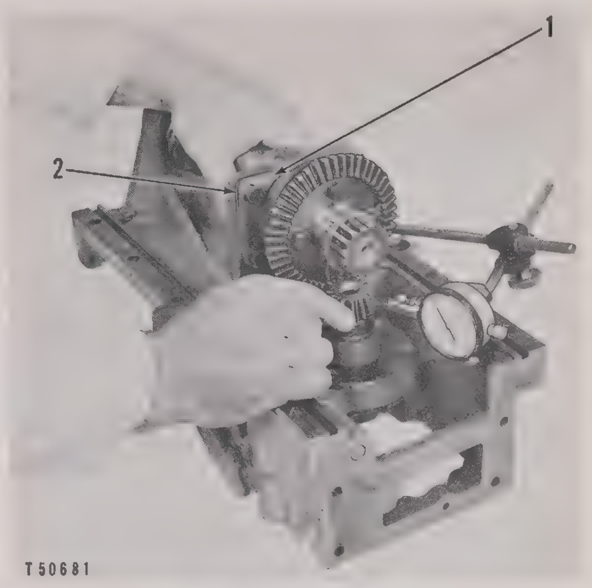
For proper drive shaft adjustment, see the topic ADJUSTMENT.

8. Inspect the parts and replace if necessary. Assemble in reverse order of disassembly installing the required number of shims between gear **(11)** and shaft **(14)** for proper alignment of the tachometer drive gears.

Adjustment

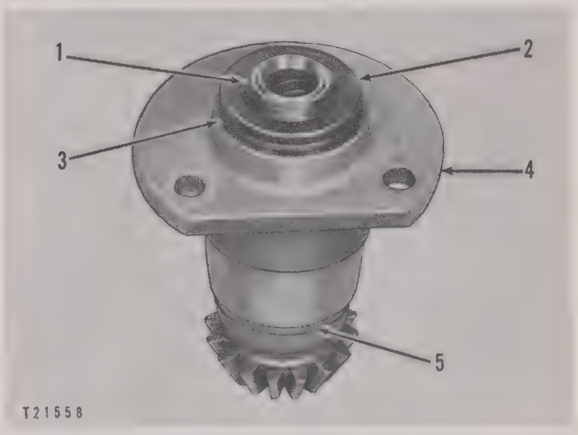
To check the backlash between the pinion and drive gear, set up a dial indicator as shown in the illustration.

Adjust the backlash to the value given in the SPECIFICATIONS by removing or adding shims **(2)** behind thrust plate **(1)**.



CHECKING BACKLASH
1–Thrust plate. 2–Shims.

Governor Drive Pinion Disassembly and Assembly



REMOVING THE PINION AND BEARINGS
1–Pinion. 2–Washer. 3–Bearing. 4–Cage assembly. 5–Bearing.

1. Use a suitable spacer and press pinion **(1)** from cage assembly **(4)** and remove washer **(2)**.

2. Install a new cage assembly if bearings **(3)** and **(5)** are unfit for further use.

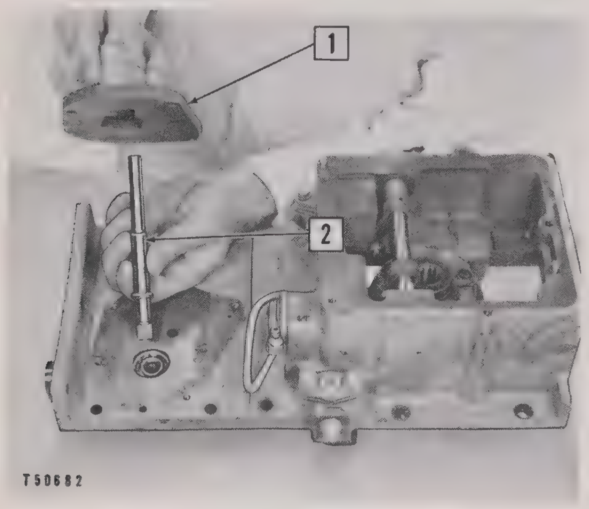
3. Install the pinion and press the washer onto the pinion.

NOTE

With the washer pressed tight against the shoulder of the pinion, the cage assembly must have .002" - .006" end clearance.

TACHOMETER DRIVE

Removal and Installation

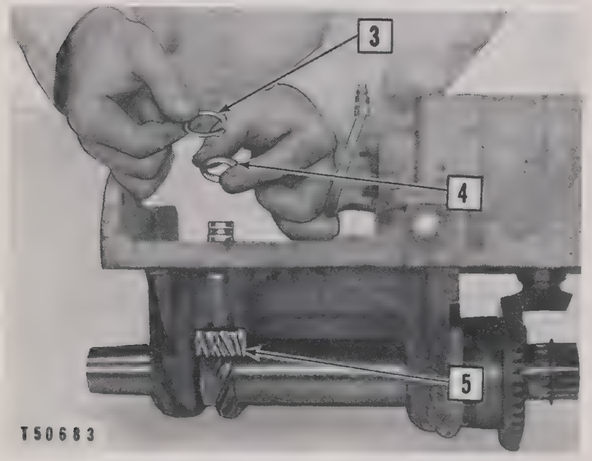


REMOVAL OF TACHOMETER DRIVE
1–Cover. 2–Drive shaft.

Replace shaft **(2)** if worn or damaged.

Push gear **(5)** up to allow access to retainer **(4)**.

Replace the bearing if necessary.



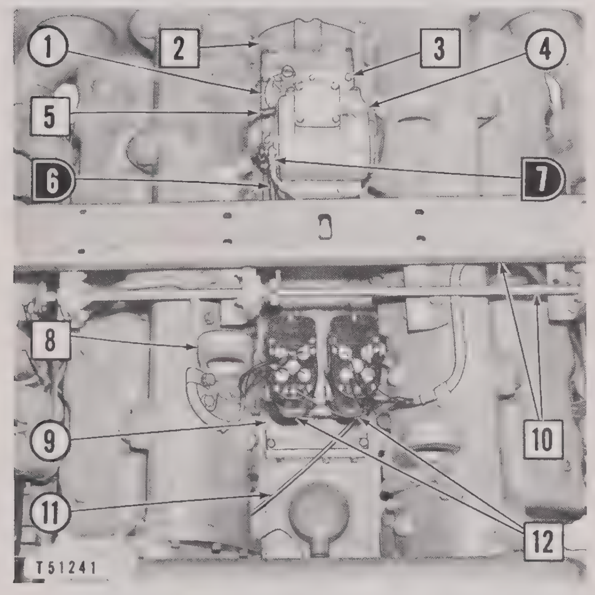
REMOVING TACHOMETER DRIVE GEAR
3–Snap ring. 4–Retainer. 5–Drive gear.

Magneto and Governor Drive

(Natural Gas Engines)

REMOVAL AND INSTALLATION

1. Remove the magneto cover if so equipped.
2. Place identification marks on all ignition leads so they can be installed in the correct order, and remove them from magnetos **(12)**.
3. Disconnect left choke cable **(11)** at left carburetor and position the cable so as to provide clearance for magneto drive housing removal.



REMOVING MAGNETO AND GOVERNOR DRIVE
1–Governor drive housing. 2–Governor and magneto gear cover. 3–Bolts (twenty-eight). 4–Governor. 5–Oil line. 6–Carburetor control linkage. 7–Governor control linkage. 8–Lifting bracket. 9–Magneto drive housing. 10–Governor and carburetor control brackets. 11–Left choke cable. 12–Magnetos.

4. Attach a sling and hoist and lift governor **(4)**, governor drive housing **(1)** and magneto drive housing **(9)** off engine as a unit.
5. Check all parts for damage or wear.

NOTE

See the topic, TIMING THE MAGNETOS, for timing instructions.

GOVERNOR DRIVE HOUSING

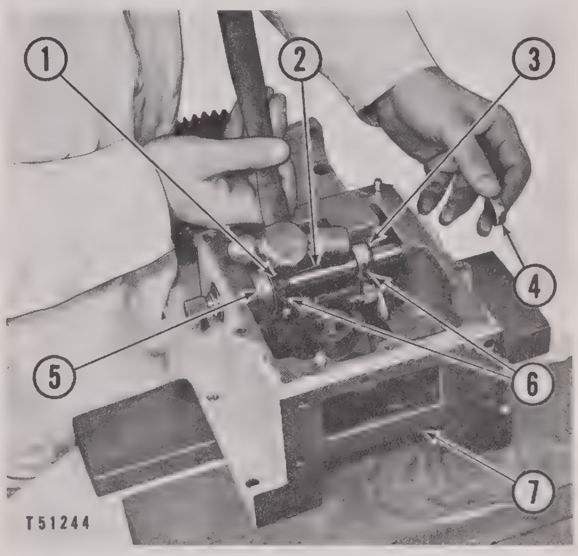
Disassembly and Assembly

1. Remove the governor, governor drive housing, and magneto drive housing as a unit. See the covering topic.
2. Separate the governor and magneto drive housings from the governor drive housing. See the covering topic.

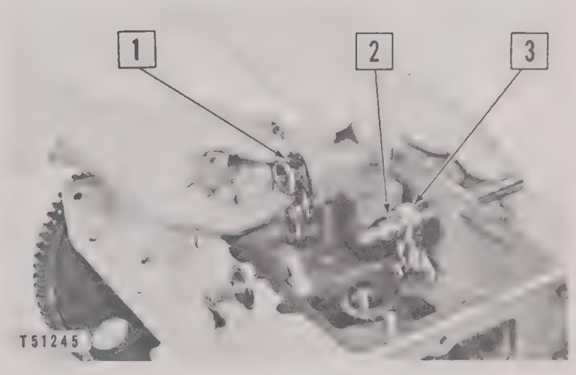
NOTE

See the topic, FUEL PUMP AND GOVERNOR DRIVE, for information on the governor drive pinion, drive shaft, tachometer drive and various adjustment procedures.

3. Support the governor drive housing in an upright position as shown for best accessibility.

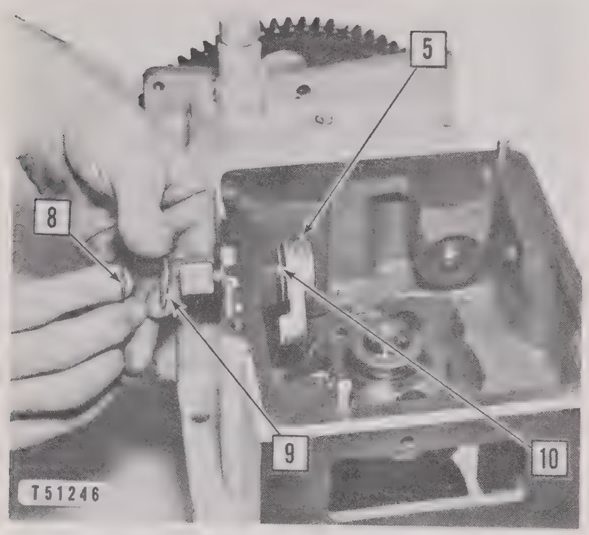


PREPARING TO REMOVE SHAFT
1–Lever. 2–Shaft. 3–Lever. 4–Plug. 5–Lever assembly. 6–Spring pins. 7–Governor drive housing.

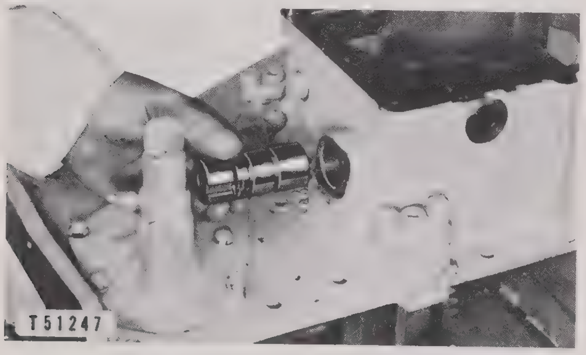


REMOVING SHAFT
1–Lever. 2–Shaft. 3–Lever.

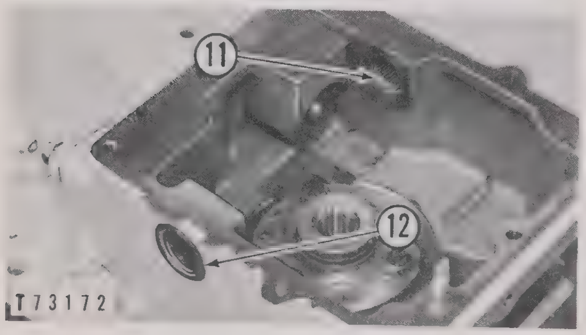
4. Force shaft **(2)** and levers **(1)** and **(3)** out of lever assembly **(5)** as a unit and drive plug **(4)** out of governor drive housing **(7)**.
5. Remove spring pins **(6)** from levers **(1)** and **(3)**.
6. Inspect the linkage on levers **(1)** and **(3)**.
7. Inspect the thrust washer **(10)**.
8. Remove the cover over the servo-valve in the governor drive housing and remove the valve.
9. Inspect bearing **(11)** and bearing and seal **(12)**.



REMOVING LEVER ASSEMBLY
5–Lever assembly. 8–Ring. 9–Washer. 10–Thrust washer.



REMOVING SERVO-VALVE



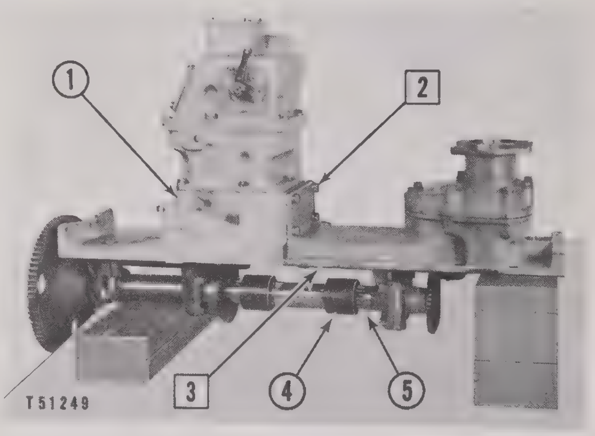
SHAFT BEARINGS
11–Bearing. 12–Bearing and seal.

10. Replace gaskets, if necessary.

MAGNETO DRIVE

Removal and Installation

Remove the magneto and governor drive from the engine as a unit as described in the covering topic, and position the unit as shown.

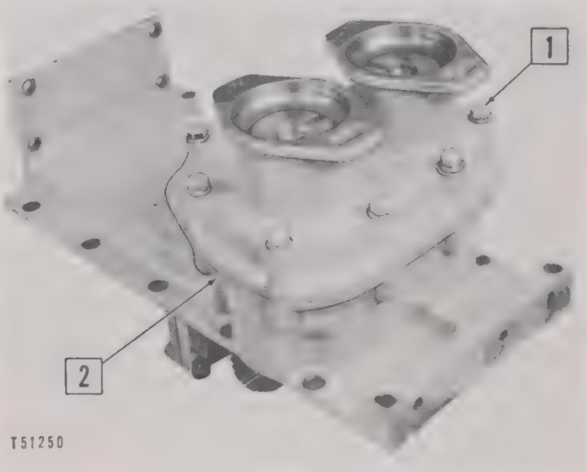


REMOVING MAGNETO DRIVE
1–Governor drive housing. 2–Bolts.
3–Magneto drive housing.

Hold governor drive housing **(1)** and slide magneto drive housing **(3)** forward to disengage shaft **(5)** from coupling **(4)**.

Install in reverse order of removal.

Disassembly and Assembly of Cover Assembly



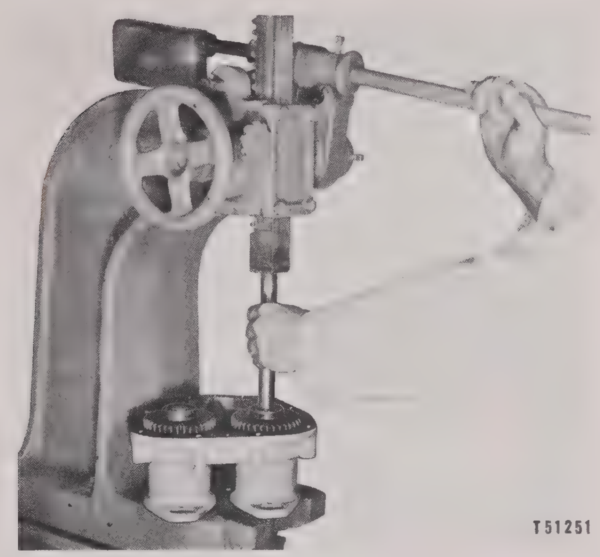
COVER ASSEMBLY REMOVAL
1–Bolts (eight). 2–Cover assembly.

Press shaft **(6)** from gear **(3)** as shown. Remove collar **(7)** in a similar manner.

Inspect bearings **(5)** and washer **(4)**.

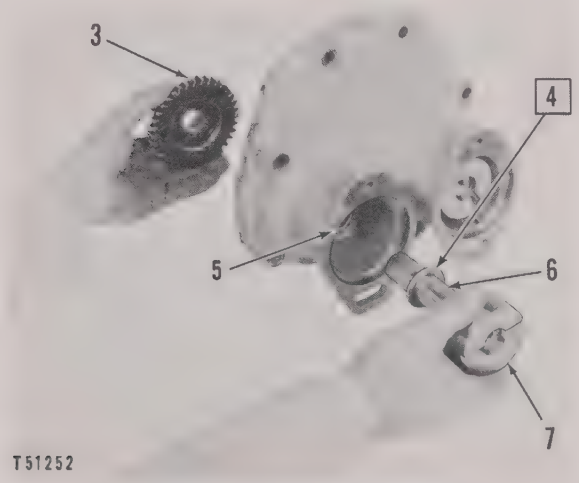
NOTE

When assembling the cover assembly, press collar **(7)** on shaft **(6)** to dimension **(A)** and gear **(3)** to dimension **(B)**.

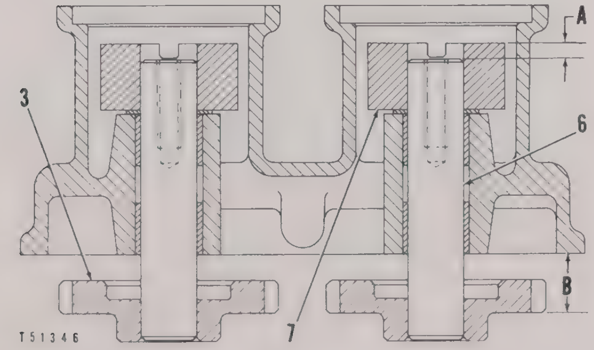


PREPARING TO DISASSEMBLE COVER ASSEMBLY

Disassemble, inspect, and assemble the other magneto drive in a similar manner.

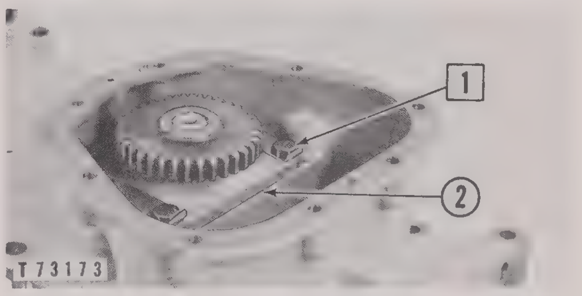


DISASSEMBLING COVER ASSEMBLY
3–Gear. 4–Washer. 5–Bearings (two). 6–Shaft. 7–Collar.



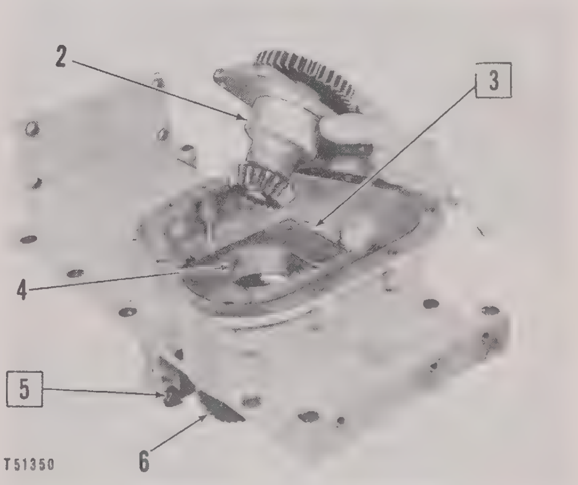
ASSEMBLING COVER ASSEMBLY
3–Gear. 6–Shaft. 7–Collar. A–.250". B–1.00".

Disassembly and Assembly of Magneto Drive Housing

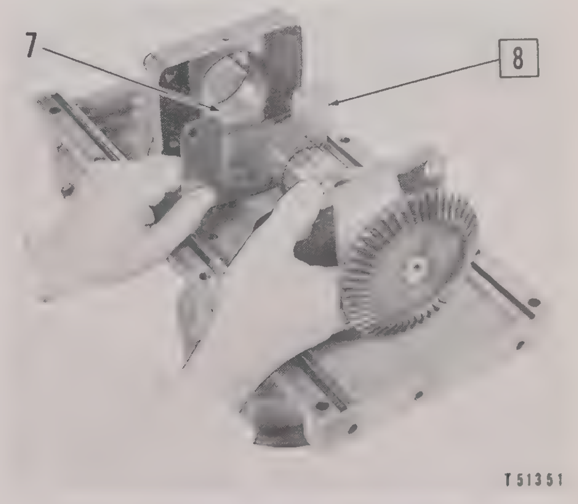


PREPARING TO DISASSEMBLE MAGNETO DRIVE HOUSING
1–Bolts (four) and locks (two). 2–Pinion assembly.

1. Remove pinion assembly (2) as shown.



REMOVING PINION ASSEMBLY
2–Pinion assembly. 3–Shims. 4–Oil hole. 5–Bolts (four) and locks (two). 6–Bevel gear assembly.



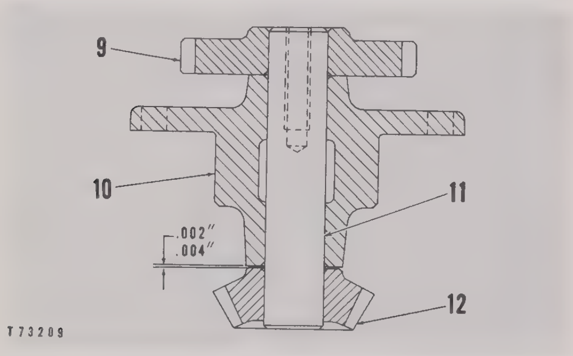
BEVEL GEAR ASSEMBLY REMOVAL
7–Oil hole. 8–Shims.

2. Remove bevel gear assembly **(6)** as shown.
3. Press shaft **(11)** from gear **(9)** and pinion **(12)**.
4. Inspect all parts for damage or wear.

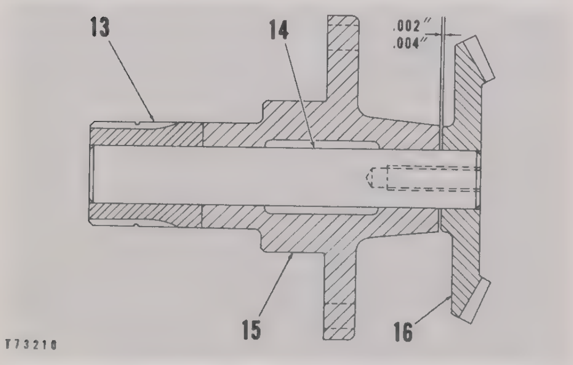
NOTE

When assembling pinion assembly, press pinion **(12)** and gear **(9)** on shaft **(11)** so there is .002" - .004" clearance between the pinion and cage **(10)**.

5. Press shaft **(14)** from splined shaft **(13)** and from bevel gear **(16)**.



PINION ASSEMBLY
9–Gear. 10–Cage. 11–Shaft. 12–Pinion.



BEVEL GEAR ASSEMBLY
13–Splined shaft. 14–Shaft. 15–Cage. 16–Bevel gear.

6. Inspect all parts for damage or wear.

NOTE

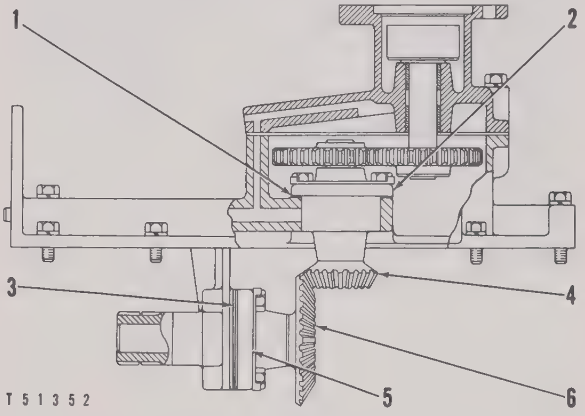
When assembling the bevel gear assembly, press splined shaft **(13)** and bevel gear **(16)** on shaft **(14)** so there is .002" - .004" clearance between the bevel gear and cage **(15)**.

7. When assembling, align oil holes **(4)** and **(7)**. See topic, TOOTH CONTACT AND BACKLASH ADJUSTMENT for correct use of shims.

Tooth Contact and Backlash Adjustment

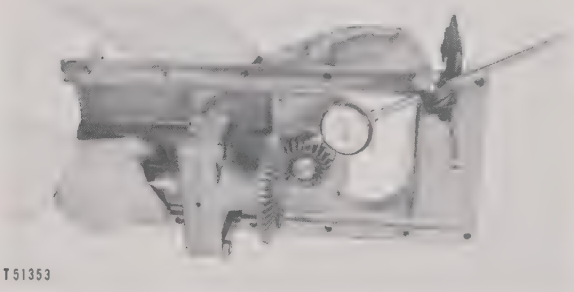
The tooth contact and backlash between the bevel gear and pinion must be adjusted if either the bevel gear or pinion is replaced.

1. Add or remove shims **(1)** between the housing and the pinion flange **(2)** until the heels of the bevel gear **(6)** and the pinion **(4)** are in alignment. This is the correct tooth contact.



ADJUSTING MAGNETO DRIVE
1–Shims. 2–Pinion flange. 3–Shims. 4–Pinion.
5–Bevel gear flange. 6–Bevel gear.

2. Mount a dial indicator as shown with the indicator touching a pinion tooth.



MOUNTING DIAL INDICATOR

3. Hold bevel gear shaft so bevel gear will not move.
4. Twist the pinion shaft back and forth noting the total movement indicated on the dial indicator. This total movement is the backlash between the bevel gear and the pinion.
5. Add or remove shims **(3)** to adjust the backlash. See the SPECIFICATIONS.

INTRODUCTION

A line pressure regulator is required on turbocharged and aftercooled engines. In addition, naturally aspirated engines with a gas supply pressure exceeding the inlet pressure differential between the gas and air must use a regulator.

OPERATION

Gas flows through inlet **(12)** (Fig.1), orifice **(6)**, past valve disc **(5)** and through outlet **(4)**. Lower chamber **(8)** senses outlet pressure.

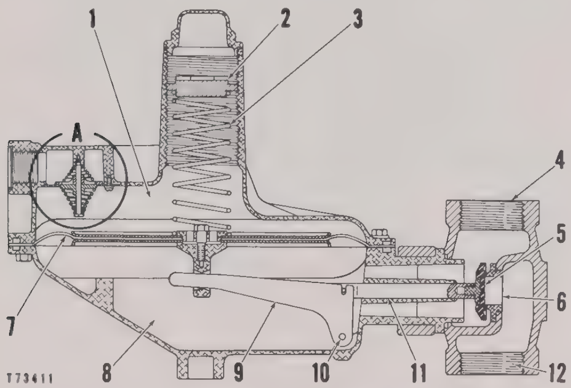


FIG. 1. REGULATOR OPERATION
1–Upper chamber. 2–Adjusting screw. 3–Spring. 4–Outlet. 5–Valve disc. 6–Orifice. 7–Diaphragm assembly. 8–Lower chamber. 9–Lever. 10–Pin. 11–Valve stem. 12–Inlet. A–Vent valve.

As gas pressure in lower chamber increases to a value higher than the force of spring **(3)** and air pressure in upper chamber **(1)** (atmosphere on naturally aspirated engines and turbocharger boost on turbocharged engines), diaphragm assembly **(7)** is forced upward. This pivots lever **(9)** about pin **(10)** and causes valve stem **(11)** to move valve disc **(5)** to close inlet orifice **(6)**.

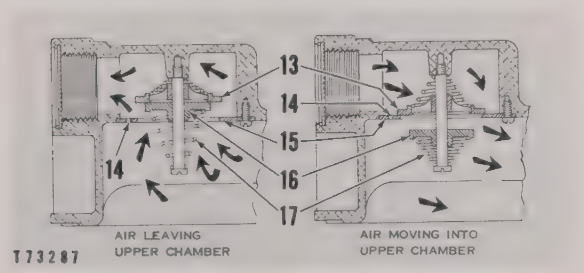


FIG. 2. DETAIL A—VENT VALVE OPERATION
13–Upper flapper. 14–Orifice. 15–Orifice plate. 16–Lower flapper. 17–Springs (two).

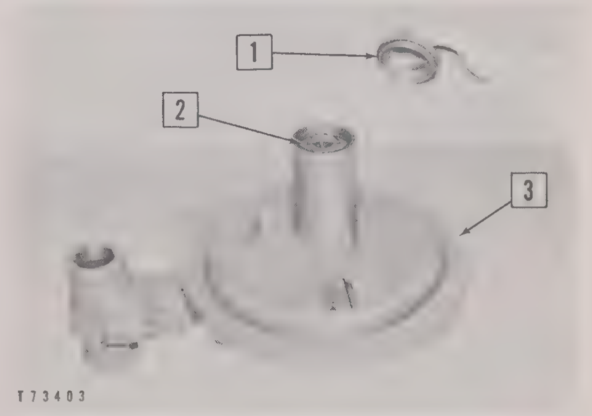
As diaphragm assembly **(7)** is forced upward, air is expelled from the upper chamber (Fig. 2). This movement of air forces lower flapper **(16)** upward, carrying upper flapper **(13)** with it. The trapped air is permitted to escape. This is accomplished quickly enough to prevent any lag in the main diaphragm assembly movement due to air compression.

With orifice **(6)** closed (Fig. 1), gas is pulled from lower chamber **(8)** through outlet **(4)**. This reduces the pressure in the lower chamber. As this pressure becomes less than that in the upper chamber, spring **(3)** and the air pressure in the upper chamber forces diaphragm assembly downward. This opens orifice **(6)** and allows additional gas flow to the regulator.

As diaphragm assembly **(7)** moves downward, air rushes inward to fill the partial vacuum created in the upper chamber (Fig. 2). This forces upper flapper **(13)** down against orifice plate **(15)**. Air going through webs in upper flapper opens lower flapper **(16)** and fills upper chamber.

When the pressures above and below the diaphragm assembly are equal, the regulator supplies gas to the carburetor at a constant pressure differential above the incoming air. Orifice **(14)** allows passage of air when pressure changes on either side of diaphragm assembly are not sufficient to overcome spring **(17)**. The regulator is adjusted by turning adjusting screw **(2)**. See the topic, AIR INDUCTION AND EXHAUST SYSTEM.

DISASSEMBLY AND ASSEMBLY



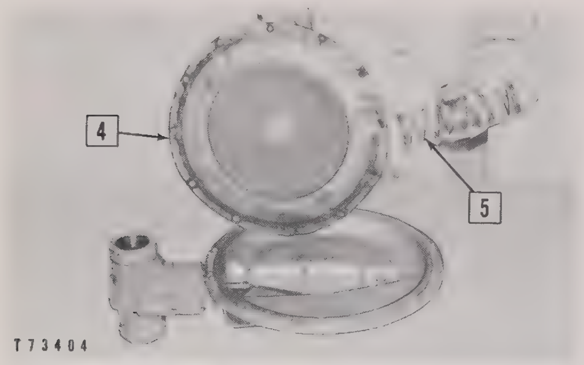
PREPARING TO DISASSEMBLE REGULATOR
1–Cap. 2–Adjusting screw. 3–Spring casing.

NOTE

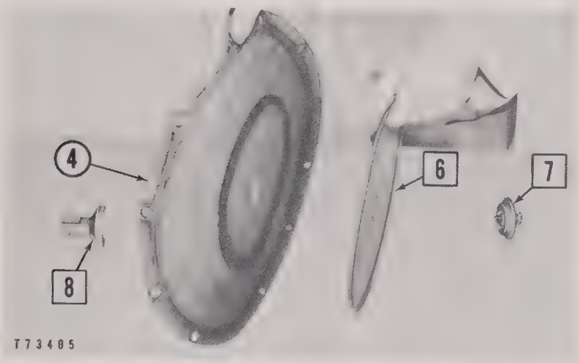
Later regulators use a solid adjusting screw **(2)** (that is, no center hole).

NOTE

Later regulators have two plates **(6)**, one on each side of diaphragm **(4)**.



REMOVING DIAPHRAGM
4–Diaphragm. 5–Spring.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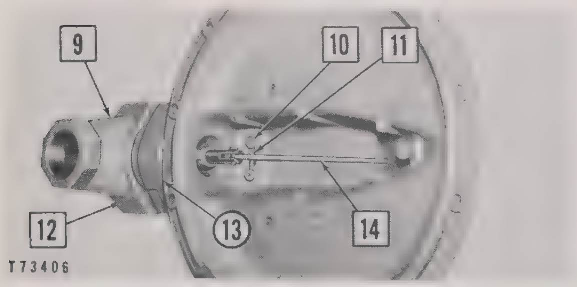
DISASSEMBLING DIAPHRAGM
4–Diaphragm. 6–Plate. 7–Spring seat and bolt. 8–Post.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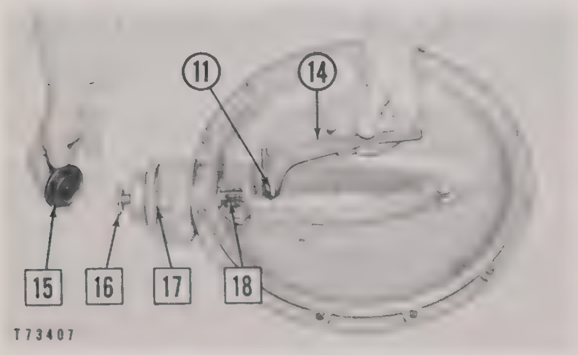
DISASSEMBLING DIAPHRAGM CASING
9–Valve body. 10–Screws (two). 11–Pin. 12–Bolts (two). 13–Rotating flange. 14–Lever.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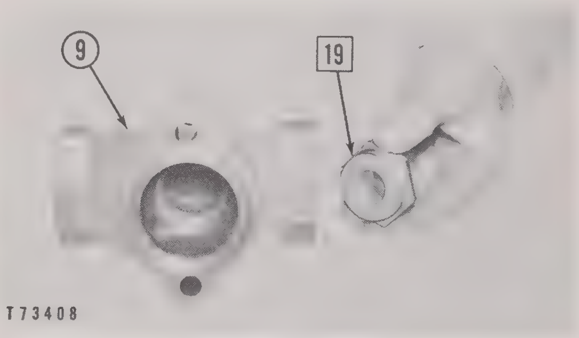
DISASSEMBLING DIAPHRAGM CASING
11–Pin. 14–Lever. 15–Valve disc. 16–Valve disc holder. 17–Seal. 18–Valve stem.

NOTE

During assembly, the casing can be rotated to any position relative to valve body **(9)**. Install bolts **(12)** through valve body into rotating flange **(13)**. Position casing and tighten bolts.

NOTE

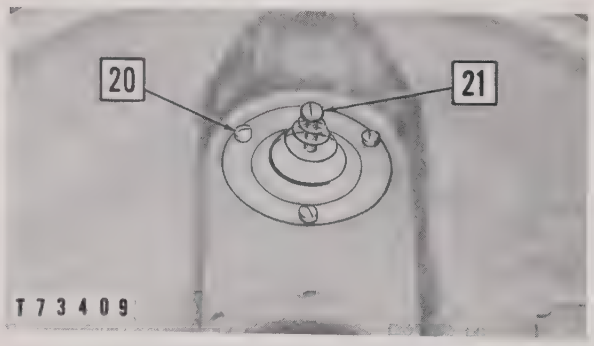
Valve disc holder **(16)** is threaded into valve stem **(18)**.



REMOVING ORIFICE
9–Valve body. 19–Orifice.

NOTE

Orifice **(19)** and valve disc **(15)** can be replaced without removing valve body **(9)** from the line or breaking any pipe connections.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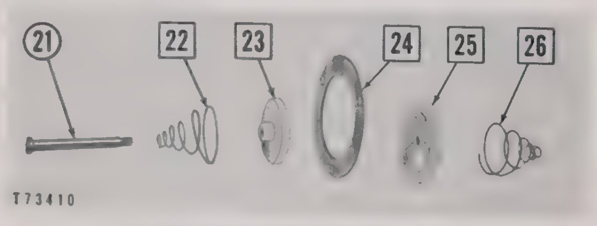
DISASSEMBLING SPRING CASING
20–Screws (three). 21–Screw.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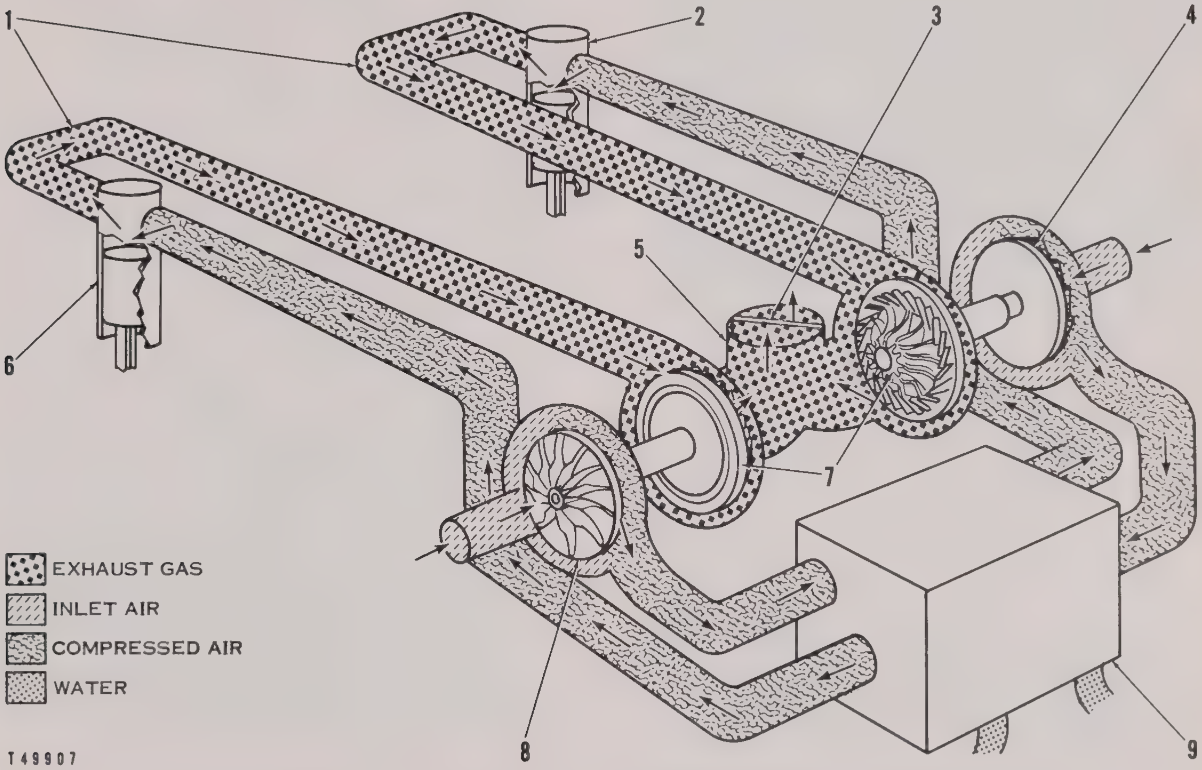
DISASSEMBLING VENT VALVE
21–Screw. 22–Spring. 23–Lower flapper. 24–Orifice plate. 25–Upper flapper. 26–Spring.

Inspect all parts.

Air Induction and Exhaust System

OPERATION



AIR INDUCTION AND EXHAUST SYSTEM

1–Exhaust manifolds.
2–Right cylinder bank.
3–Diffuser plate.
4–Right turbocharger impeller.
5–Exhaust elbow.
6–Left cylinder bank.
7–Turbocharger turbine wheels.
8–Left turbocharger impeller.
9–Aftercooler.

This engine incorporates the use of two exhaust gas driven turbochargers. Energy which ordinarily would be lost from the diesel engine exhaust gases is used to drive the turbochargers.

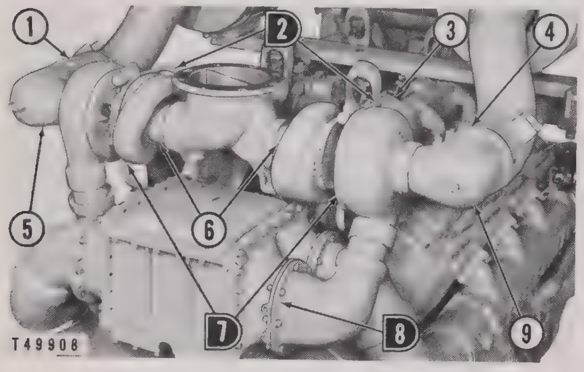
The engine is cross-blown, that is, the right turbocharger furnishes air to the left cylinder bank **(6)** and the left turbocharger furnishes air to the right cylinder bank **(2)** thus reducing the amount of piping needed to control the flow of air.

As the diesel engine starts, the flow of gases from the diesel engine exhaust manifolds **(1)** is directed to the turbine wheels **(7)** through the vanes on the nozzle. The turbine wheels of the turbochargers are mounted on a common shaft with the impellers **(4)** and **(8)**. The exhaust gases pass over the turbine wheels forcing them and the impellers to rotate. The exhaust gases then pass out of the turbochargers to the exhaust elbow **(5)** and out the exhaust stack. The exhaust elbow has a cast-in diffuser plate **(3)** in the center which keeps the flow of exhaust gases from the turbochargers separated until they reach the exhaust stack and thus reduce the exhaust back pressure.

As more fuel is added to the air-fuel mixture, more energy is passed on to the exhaust gases. The turbine wheel speed is increased and the impeller speed is increased the same amount to force additional air into the engine cylinders. Speed of the rotating parts also increases when the engine load increases because additional energy is again imparted to the exhaust gases. When the load is reduced, or engine speed changed from high idle to low idle, the exhaust gas energy is reduced and less air passes through the impeller.

A water-cooled heat exchanger, known as an aftercooler **(9)**, is installed between the compressor housing and air inlet manifold. Since the air is heated as it passes through the impeller, the aftercooler is used to reduce the compressed air temperature. A lower air temperature makes the air more dense and enables more pounds of air to be packed into the engine cylinders. More available oxygen for combustion results in more horsepower developed.

TURBOCHARGER REMOVAL

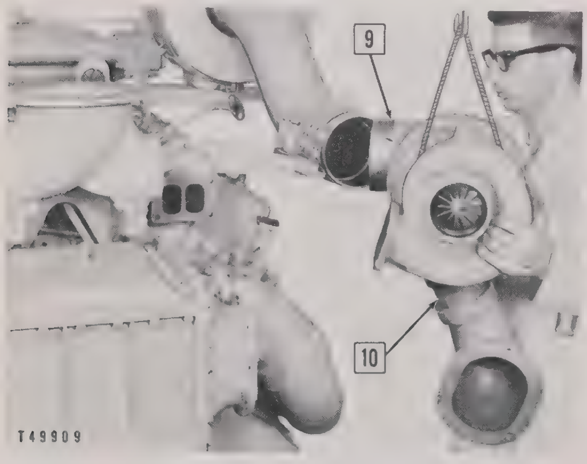


PREPARING TO REMOVE TURBOCHARGER

D Disconnect

1–Hose clamps. 2–Turbocharger lubricating oil lines. 3–Exhaust manifold. 4–Hose clamps. 5–Elbow. 6–Couplings. 7–Oil return lines. 8–Elbows (two). 9–Elbow.

1. Attach a suitable hoist to the turbocharger and remove the bolts securing the turbocharger to the exhaust manifold **(3)**.
2. Remove the bolts securing the elbows **(5)** and **(9)** to the brackets.
3. Loosen the clamps **(1)** and **(4)** and remove the right turbocharger as shown.
4. Proceed in like manner and remove the left turbocharger.



REMOVING THE TURBOCHARGER

☐ Remove

9–Elbow. 10–Pipe.

NOTE

Each coupling **(6)** should be removed as soon as the turbocharger is free.

CAUTION

After the turbocharger is removed, cover all the oil and air openings and store in a clean place until reconditioned or installation.

TURBOCHARGER INSTALLATION

Before assembling the elbows for installing the turbocharger, lubricate the turbocharger shaft with clean crankcase oil through the oil inlet hole and turn the shaft a few turns by hand. This is necessary to prevent the bearings from overheating before the engine oil can be pumped to the turbocharger shaft during the initial starting period.

Clean all mating surfaces and replace worn or damaged gaskets and O-ring seals.

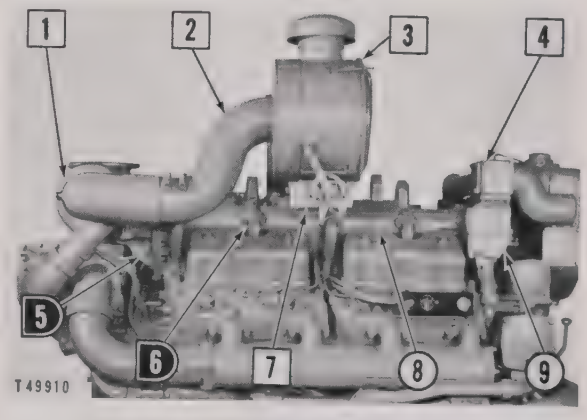
Install the turbocharger in the reverse order of removal being certain that all connections are tight.

NOTE

The turbocharger requires no special test procedure. However, observe the turbocharger for the initial one-half hour of operation to determine that the unit is secure and that no lubrication leaks develop. Thereafter, frequent periodic checks should be made as outlined in the Operation and Maintenance Instructions.

EXHAUST MANIFOLD

Removal and Installation



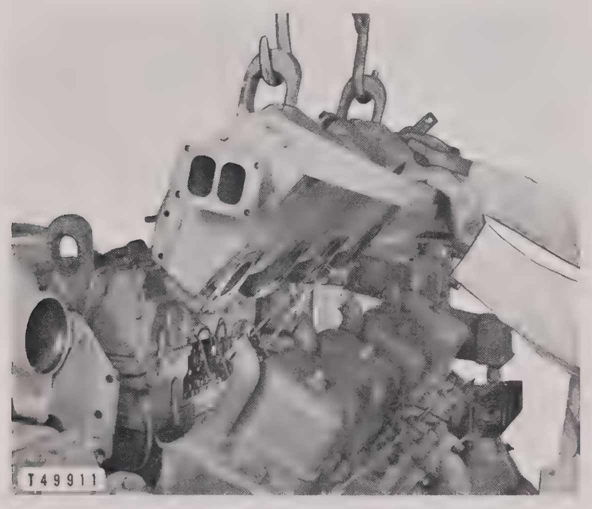
PREPARING TO REMOVE EXHAUST MANIFOLD
(D379 Illustrated)

☐ Remove **D** Disconnect

1–Turbocharger. 2–Pipe. 3–Air cleaners. 4–Pipe. 5–Bracket. 6–Elbows (one per cylinder). 7–Governor control and air cleaner support bracket. 8–Exhaust manifold. 9–Water temperature regulator housing.

1. Attach a suitable hoist to the exhaust manifold **(8)** and remove the bolts securing it to the cylinder heads.

2. Remove the bolts securing the regulator housing **(9)** to the adapter on the end of the exhaust manifold.
3. Disconnect the water temperature bulb from the adapter.
4. Remove the aftercooler vent tube.
5. Disconnect the exhaust manifold water drain tube assembly at the front and remove the exhaust manifold as shown.



REMOVING THE EXHAUST MANIFOLD

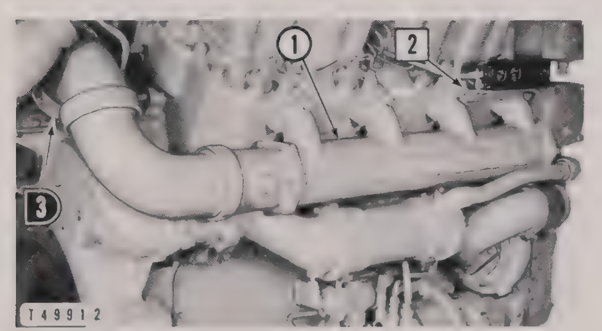
6. Replace all gaskets and O-ring seals.
7. Install in the reverse order of removal.

NOTE

The exhaust manifolds are identical and can be installed on either bank by turning them 180°. Removal is the same for both manifolds.

INLET MANIFOLD

Removal and Installation



PREPARING TO REMOVE INLET MANIFOLD

☐ Remove ■ Disconnect

1–Inlet manifold. 2–Gauges and support bracket. 3–Inlet manifold elbow.

Remove the bolts securing the inlet manifold **(1)** to the cylinder heads and remove it from the engine.

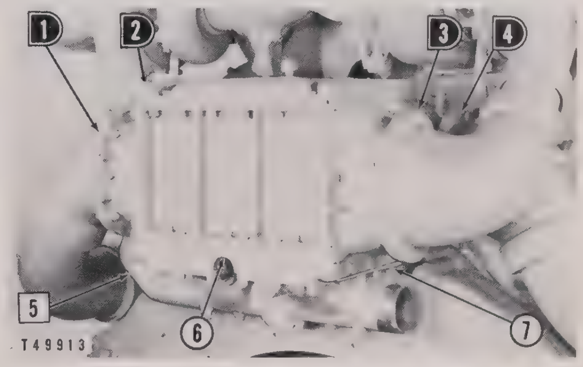
Replace the gaskets and O-ring seals on the inlet manifold and install in the reverse order of removal.

AFTERCOOLER

The aftercooler is mounted on the top of the flywheel housing. Water, circulated through the aftercooler, cools the air that has been compressed by the turbochargers. Since cooler air is more dense, a greater weight of air will enter the engine cylinders which results in more efficient burning of fuel and an increase in power.

The aftercooler is constructed so that water from the engine cooling system circulates through it to cool the air. The aftercooler assembly can be turned 180° and an adapter added to use raw water as the coolant. When the raw water adapter is used, the baffle in the flywheel housing should be removed so there will be no restriction in the engine cooling system.

Removal and Installation



PREPARING TO REMOVE THE AFTERCOOLER
(Raw Water Cooler Illustrated)

☐ Remove ■ Disconnect

1–Inlet manifold elbow. 2–Turbocharger outlet elbow. 3–Turbocharger outlet elbow. 4–Inlet manifold elbow. 5–Raw water cooling adapter. 6–Aftercooler assembly. 7–Aftercooler support bracket on flywheel housing.

1. Remove two bolts from the top of the aftercooler assembly **(6)** and install two 3/8″ - 16 (NC) lifting eyes.
2. Attach a suitable hoist to the aftercooler and remove the bolts securing the aftercooler to the support **(7)** on the flywheel housing.

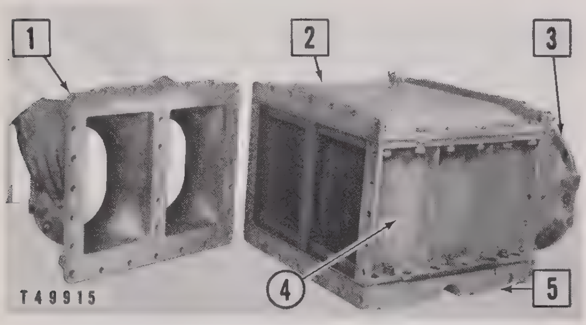
NOTE

On aftercoolers that are cooled with engine coolant, a vent line from the aftercooler to the exhaust manifold must be removed.

3. Remove the aftercooler as illustrated.
4. Install in the reverse order of removal.

REMOVING THE AFTERCOOLER

Disassembly and Assembly



PREPARING TO DISASSEMBLE AFTERCOOLER

☐ Remove

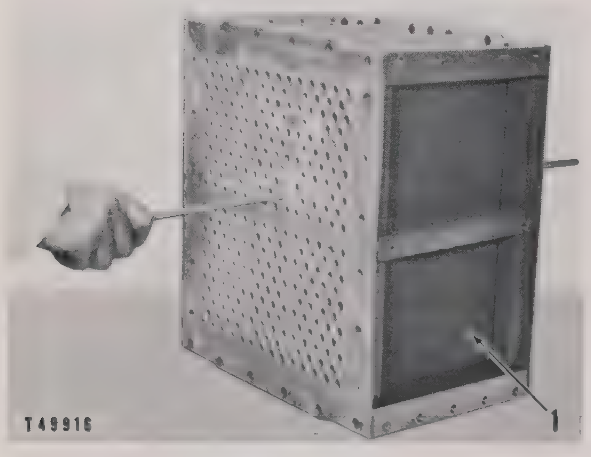
1–End cover. 2–Top cover. 3–End cover.
4–Side covers. 5–Base.

Remove the side covers **(4)** when reconditioning.

Replace all gaskets and use gasket cement when assembling the aftercooler.

Assemble in the reverse order of disassembly.

Cleaning



CLEANING THE CORE
1–Air passages.

Clean the water passage with a rod 5/16" in diameter as shown.

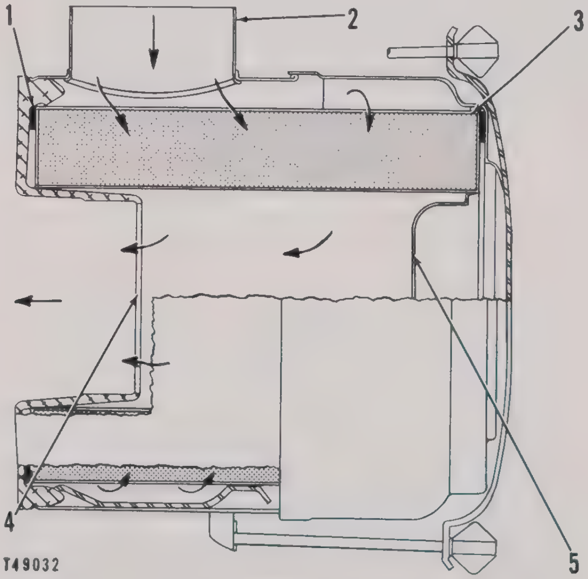
Blow out the water passages with compressed air after cleaning.

Blow out the air passages **(1)** with compressed air.

AIR CLEANER

Two dry-type air cleaners which contain replaceable filter elements **(3)** are mounted on the engine. The element can be removed and then cleaned by air pressure or by washing as recommended in the Operation and Maintenance Instructions.

During operation, air enters the air cleaner at **(2)**, flows around the outside and through the filter element **(3)** to the center of the air cleaner. The filtered air then leaves the air cleaner at **(4)** and passes to the turbocharger. Air is prevented from by-passing the filter element by the seal **(1)**. A plate **(5)** seals one end of the filter element.



AIR CLEANER AIR FLOW
1–Seal. 2–Air cleaner inlet. 3–Filter element.
4–Air cleaner outlet. 5–Plate.

Removal and Installation

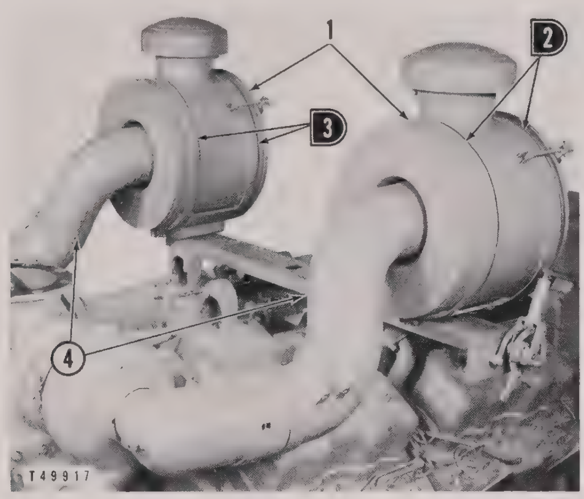
Remove the air cleaners by sliding them forward away from the elbows **(4)**.

Replace the O-ring seals before installation.

NOTE

Lubricate the seals with liquid soap to facilitate installation.

Install in the reverse order of removal.

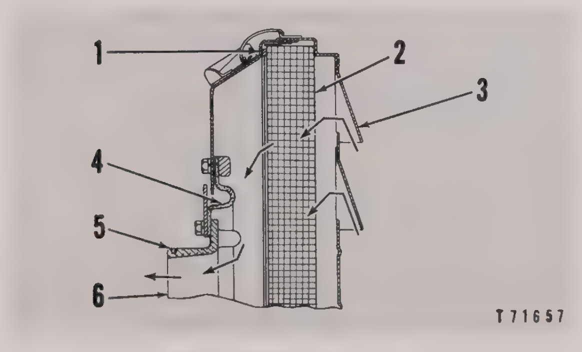


PREPARING TO REMOVE THE AIR CLEANERS

D Disconnect

1–Air cleaners. 2, 3–Straps. 4–Elbows.

PANEL TYPE AIR CLEANER

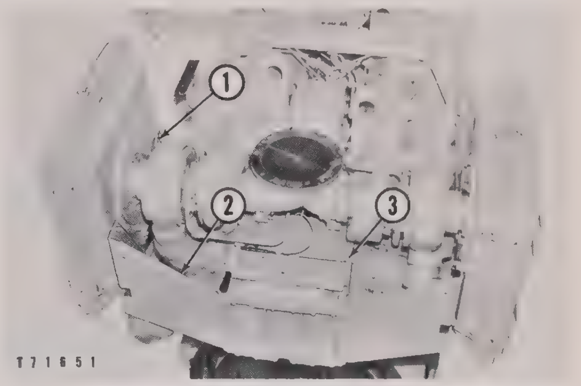


AIR CLEANER AIR FLOW
1–Gasket. 2–Filter element. 3–Cover. 4–Diaphragm.
5–O-ring. 6–Outlet to turbocharger.

The two panel-type air cleaner assemblies each contain a replaceable dry type filter element **(2)**. The element can be removed and then cleaned with air pressure or by washing. See the Operation and Maintenance Instructions.

During operation, air enters through the louvers in cover **(3)**. Gasket **(1)** prevents air from flowing around element **(2)**. As the air passes through the filter element the particles of dirt are trapped in the element. The filtered air passes through outlet **(6)** and on to the turbocharger. O-ring **(5)** forms an air tight seal between the air cleaner outlet and the turbocharger inlet. Diaphragm **(4)** absorbs vibration between the turbocharger and the air cleaner assembly.

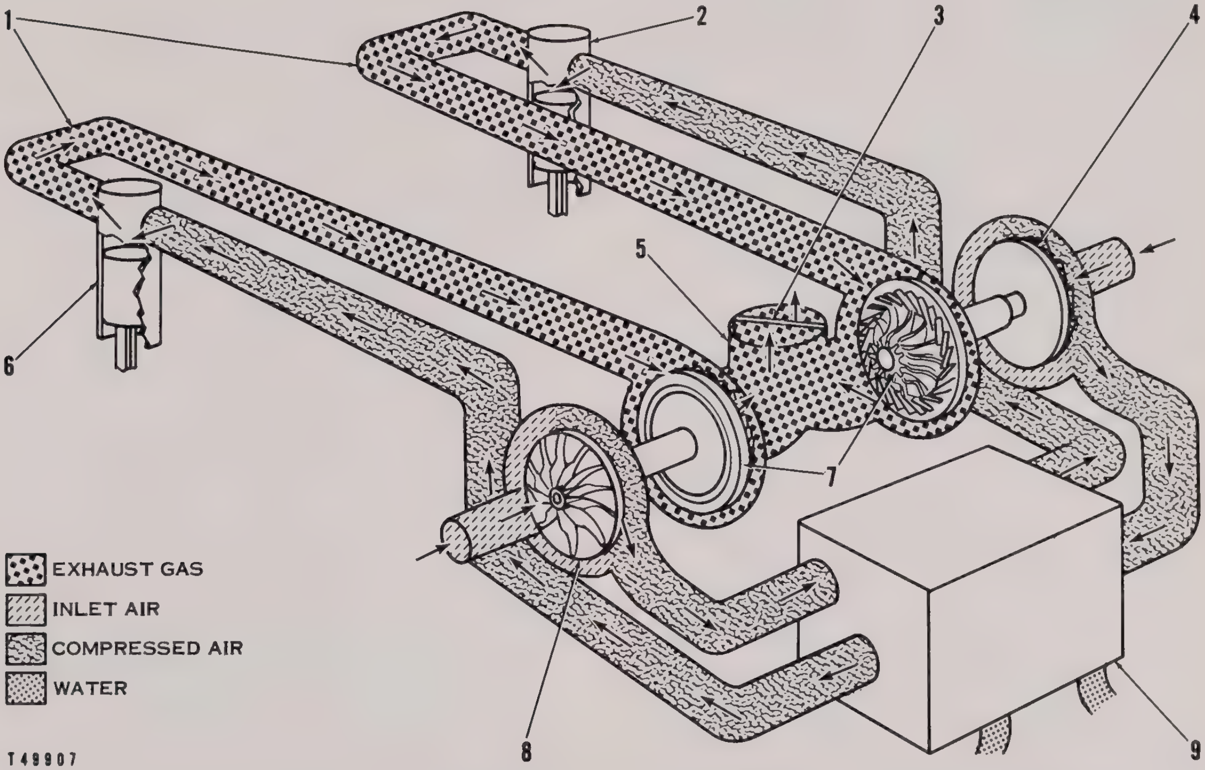
Removal and Installation



PREPARING TO REMOVE AIR CLEANER
1–Bracket. 2–Bracket. 3–Aftercooler.

1. Support the weight of the air cleaner assembly before attempting to remove the bolts securing it.
2. Remove the bolts securing bracket **(1)** to the air cleaner assembly.
3. Remove the bolts securing bracket **(2)** to aftercooler **(3)**.
4. Move the air cleaner away from the turbocharger to remove it.
5. Replace the O-ring seal before installation. Lubricate the seal with liquid soap to facilitate installation.

OPERATION



AIR INDUCTION AND EXHAUST SYSTEM

1–Exhaust manifolds.
2–Right cylinder bank.
3–Diffuser plate.
4–Right turbocharger impeller.
5–Exhaust elbow.
6–Left cylinder bank.
7–Turbocharger turbine wheels.
8–Left turbocharger impeller.
9–Aftercooler.

This engine incorporates two turbochargers. Exhaust gas energy, which is normally lost, is used to drive the turbochargers.

The engine is cross-blown, that is, the right turbocharger furnishes air to left cylinder bank **(6)** and the left turbocharger furnishes air to right cylinder bank **(2)**.

When the diesel engine is operating, the exhaust gas from cylinder banks **(2)** and **(6)** passes through manifolds **(1)** and is directed by vanes on nozzles against turbocharger turbine wheels **(7)** forcing them to rotate. When the turbine wheels rotate, right turbocharger impeller **(4)** and left turbocharger impeller **(8)** also rotate (a turbine wheel and an impeller are on a common shaft). When the impellers rotate, they draw air through the air cleaners and force this air to cylinder banks **(2)** and **(6)**.

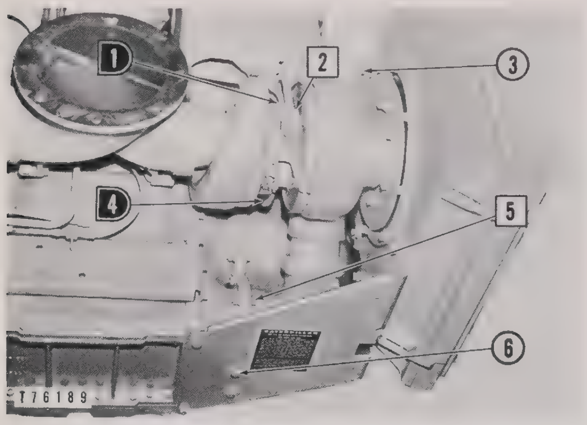
When the load on an engine is increased, more fuel is injected into the engine cylinders and a greater volume of exhaust gas is directed against the turbine wheels forcing them and the impellers to rotate faster. Engine power increases when more fuel is burned. When the load on an engine is decreased, fuel is decreased and less exhaust gas results. With less exhaust gas, the turbine wheels and impellers rotate slower and engine power decreases.

When the turbocharger compresses the inlet air for the engine cylinders, the temperature of the air increases. A water cooled aftercooler **(9)**, installed between the turbochargers and the air inlet manifolds to cylinder banks **(2)** and **(6)** will cool and condense the compressed air from the turbochargers. Cooler compressed air has more oxygen, thus more fuel can be injected. When more oxygen is present, more fuel is burned and engine power is increased.

The exhaust gas from each turbocharger passes out exhaust elbow **(5)**. A cast in diffuser plate **(3)** in the center of exhaust elbow **(5)** keeps the exhaust from each turbocharger separated to reduce exhaust back pressure.

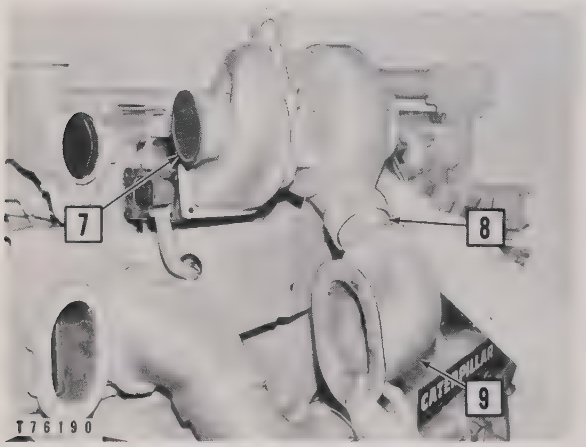
TURBOCHARGER REMOVAL

Support the weight of the air cleaner, remove bolts **(3)** and **(6)** and move the air cleaner away from the turbocharger.



PREPARING TO REMOVE TURBOCHARGER
1–Oil line. 2–Oil inlet line. 3–Bolts (three). 4–Oil return line. 5–Bolts (eight). 6–Bolts (four).

Attach a hoist to the turbocharger, remove the bolts that secure the turbocharger to the exhaust manifold and remove the turbocharger.



REMOVING THE TURBOCHARGER
7–Coupling. 8–Pipe. 9–Elbow.

Proceed in like manner and remove the left turbocharger.

CAUTION

After the turbocharger is removed, cover all the oil and air openings and store in a clean place until reconditioned or installed.

TURBOCHARGER INSTALLATION

Before installing the turbocharger, lubricate the turbocharger shaft with clean crankcase oil through the oil inlet hole and turn the shaft a few turns by hand. This is necessary to prevent the bearings from overheating before the engine oil can be pumped to the turbocharger shaft during the initial starting period.

Clean all mating surfaces and replace worn or damaged gaskets and O-ring seals.

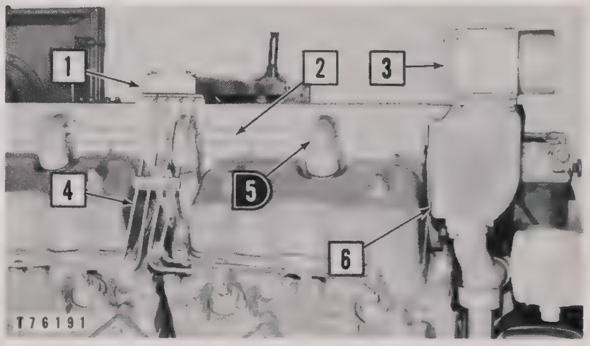
Install the turbocharger in the reverse order of removal being certain that all connections are tight.

NOTE

The turbocharger requires no special test procedure. However, observe the turbocharger for the initial one-half hour of operation to determine that the unit is secure and that no lubrication leaks develop. Thereafter, frequent periodic checks should be made as outlined in the Operation and Maintenance Instructions.

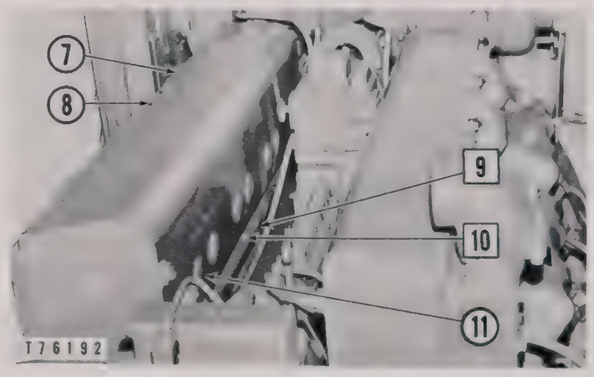
EXHAUST MANIFOLD

Removal and Installation



PREPARING TO REMOVE EXHAUST MANIFOLD WATER JACKET
(D379 Illustrated)
1–Governor control support bracket. 2–Bolts (ten). 3–Water inlet box assembly and cross pipe. 4–Fuel injection lines. 5–Elbows (two per cylinder head). 6–Water temperature regulator housing.

1. An access plug **(11)** can be removed from each end of shield assembly **(7)** and lift chain hooks placed in the access plug openings when removing the water jacket.



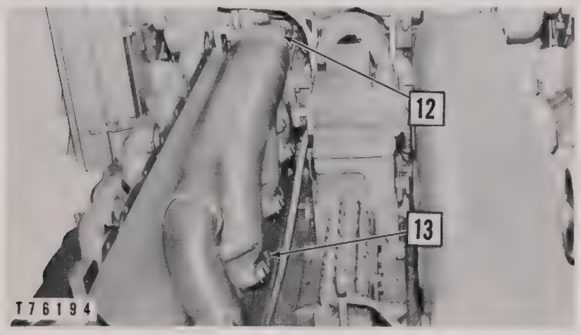
DISCONNECTING WATER JACKET
7–Shield assembly. 8–Bolt hole. 9–Shield. 10–Bolts (four). 11–Access plug.

NOTE

A lift chain with a single hook can be used when removing the water jacket if a 5/16" - 18 NC forged eyebolt is placed in bolt hole **(8)**.

2. Remove the exhaust manifold water jacket. Approximate weight 85 pounds.

REMOVING EXHAUST MANIFOLD WATER JACKET



PREPARING TO REMOVE EXHAUST MANIFOLD
(D379 Illustrated)
12–Bolts (four). 13–Bolts (eight for each cylinder head).

3. Remove the exhaust manifold. Approximate weight 40 pounds.

REMOVING THE EXHAUST MANIFOLD

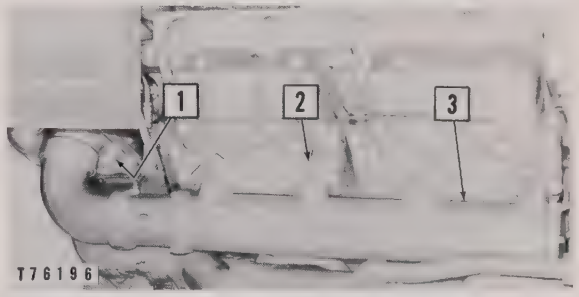
4. Proceed in like manner and remove left exhaust manifold.
5. Replace all gaskets and O-ring seals.
6. Install in the reverse order or removal.

INLET MANIFOLD

Removal and Installation

NOTE

Whenever an inlet manifold is removed, thoroughly clean the inside of the manifold including the elbows, the aftercooler end cover and the inlet air cavities in the cylinder head.



PREPARING TO REMOVE INLET MANIFOLD
(D379 Illustrated)
1–Inlet manifold elbow. 2–Bolts (six for each cylinder head). 3–Inlet manifold.

Replace the gaskets and O-ring seals on the inlet manifold and install in the reverse order of removal.

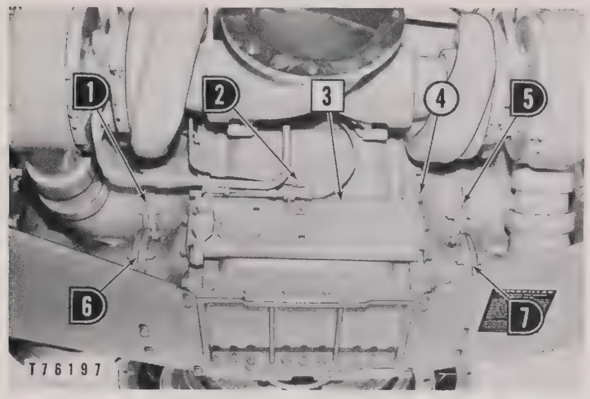
AFTERCOOLER

The aftercooler is mounted on the top of the flywheel housing. Water, circulated through the aftercooler, cools the air that has been compressed by the turbochargers. Since cooler air is more dense, a greater weight of air will enter the engine cylinders and more fuel can be burned which results in an increase in power.

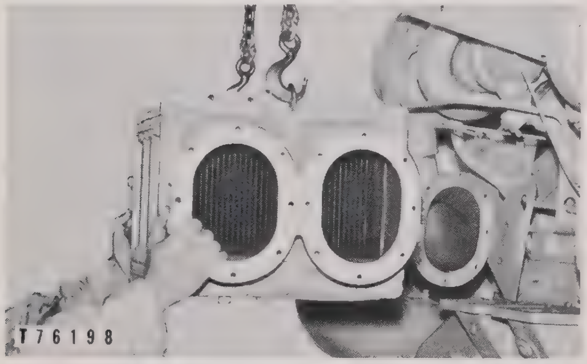
The aftercooler is constructed so water from the engine cooling system circulates through it to cool the air. The aftercooler assembly can be turned 180° and an adapter added to use raw water as the coolant. When the raw water adapter is used, the baffle in the flywheel housing should be removed so there will be no restriction in the engine cooling system.

Removal and Installation

1. Remove the air cleaners. See covering topic.
2. Remove bolt **(4)** and a bolt on the other side of the aftercooler. Insert a 3/8" - 16 NC forged eyebolt in each bolt hole.
3. Attach a hoist to the eyebolts, remove the sixteen bolts that secure the aftercooler to the flywheel housing and remove the aftercooler. Approximate weight 170 pounds.



PREPARING TO REMOVE THE AFTERCOOLER
1-Left turbocharger elbow. 2-Vent line. 3-Safety shut-off reset control bracket. 4-Bolt. 5-Right inlet manifold elbow. 6-Left inlet manifold elbow. 7-Right turbocharger elbow.



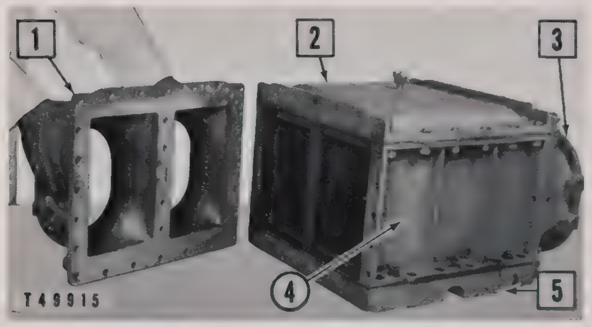
REMOVING THE AFTERCOOLER

4. Install the aftercooler in reverse order of removal.

NOTE

Before installing the aftercooler make certain the insides of the end covers have been thoroughly cleaned. If it is suspected that there are foreign particles in the inlet manifold, remove and clean the inside of the inlet manifold at this time.

Disassembly and Assembly



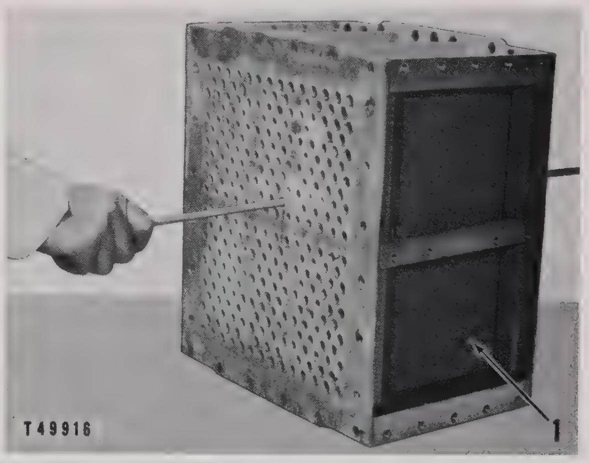
PREPARING TO DISASSEMBLE AFTERCOOLER
1-End cover. 2-Top cover. 3-End cover. 4-Side covers. 5-Base.

Remove the side covers **(4)** when reconditioning.

Replace all gaskets and use gasket cement when assembling the aftercooler.

Assemble in the reverse order of disassembly.

Cleaning



CLEANING THE CORE
1-Air passages.

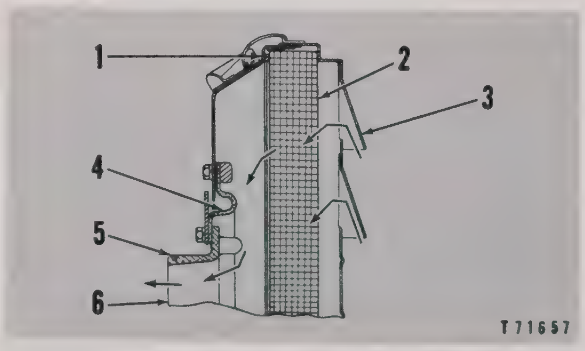
Clean the water passage with a rod 5/16" in diameter as shown.

Blow out water passages with compressed air after cleaning.

Blow out the air passages **(1)** with compressed air.

Thoroughly clean the inner surfaces of the end covers.

PANEL-TYPE AIR CLEANER

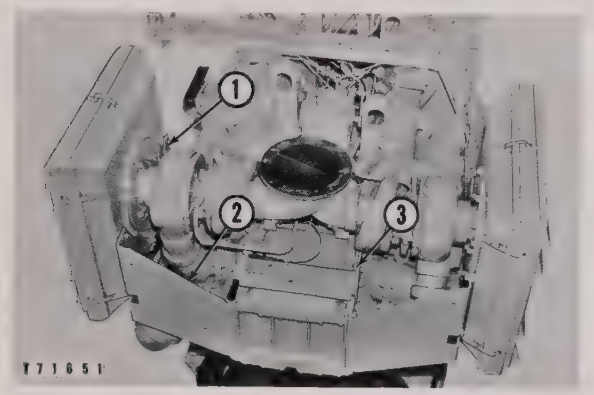


AIR CLEANER AIR FLOW
1-Gasket. 2-Filter element. 3-Cover. 4-Diaphragm. 5-O-ring. 6-Outlet to turbocharger.

The two panel-type air cleaner assemblies each contain a replaceable dry-type filter element **(2)**. The element can be removed and then cleaned with air pressure or by washing. See the Operation and Maintenance Instructions.

During operation, air enters through the louvers in cover **(3)**. Gasket **(1)** prevents air from flowing around element **(2)**. As the air passes through the filter element, the particles of dirt are trapped in the element. The filtered air passes through outlet **(6)** and on to the turbocharger. O-ring **(5)** forms an airtight seal between the air cleaner outlet and the turbocharger inlet. Diaphragm **(4)** absorbs vibration between the turbocharger and the air cleaner assembly.

Removal and Installation



PREPARING TO REMOVE AIR CLEANER
1–Bracket. 2–Bracket. 3–Aftercooler.

Support the weight of the air cleaner, remove the bolts that secure the air cleaner to bracket **(1)** and remove the bolts that secure bracket **(2)** to aftercooler **(3)**.

Move the air cleaner away from the turbocharger.

Replace the O-ring seal before installation. Lubricate the seal with liquid soap to facilitate installation.

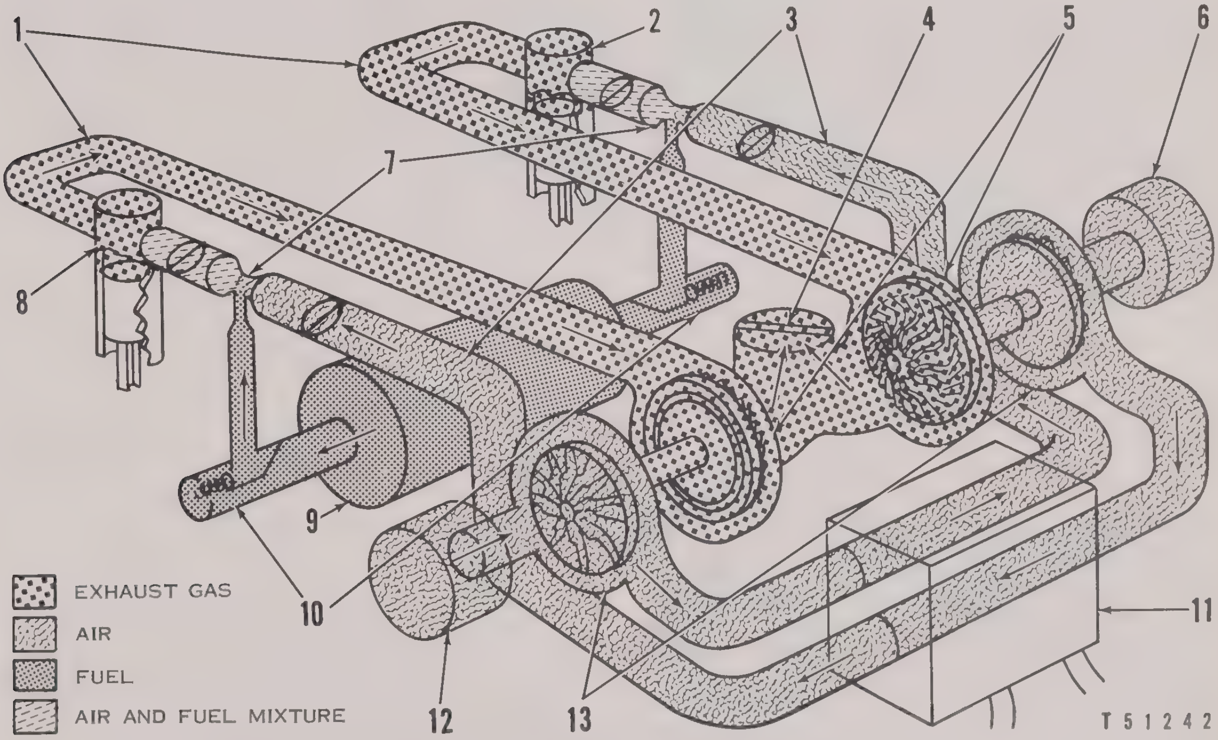
Air Induction and Exhaust System

(Natural Gas Engines)

OPERATION

The power output of gas engines is dependent upon the amount of air/fuel mixture admitted to the cylinders. This amount of mixture is controlled by a throttle disc located in each carburetor **(7)**.

For efficient engine operation, a relatively constant air/fuel mixture ratio must be maintained. Air flow is controlled by the carburetors **(7)**. Fuel flow is controlled by the carburetor regulators **(10)** and the venturi in the throat of each carburetor to maintain the definite air/fuel mixture ratio.



AIR INDUCTION AND EXHAUST SYSTEM
(Turbocharged)

- **1–Exhaust manifold.**
- **2–Right cylinder bank.**
- **3–Air inlet manifold.**
- **4–Diffuser plate.**
- **5–Turbocharger turbine wheels.**
- **6–Left bank air cleaner.**
- **7–Carburetors.**
- **8–Left cylinder bank.**
- **9–Fuel supply.**
- **10–Regulators.**
- **11–Aftercooler.**
- **12–Right bank air cleaner.**
- **13–Turbocharger impellers.**

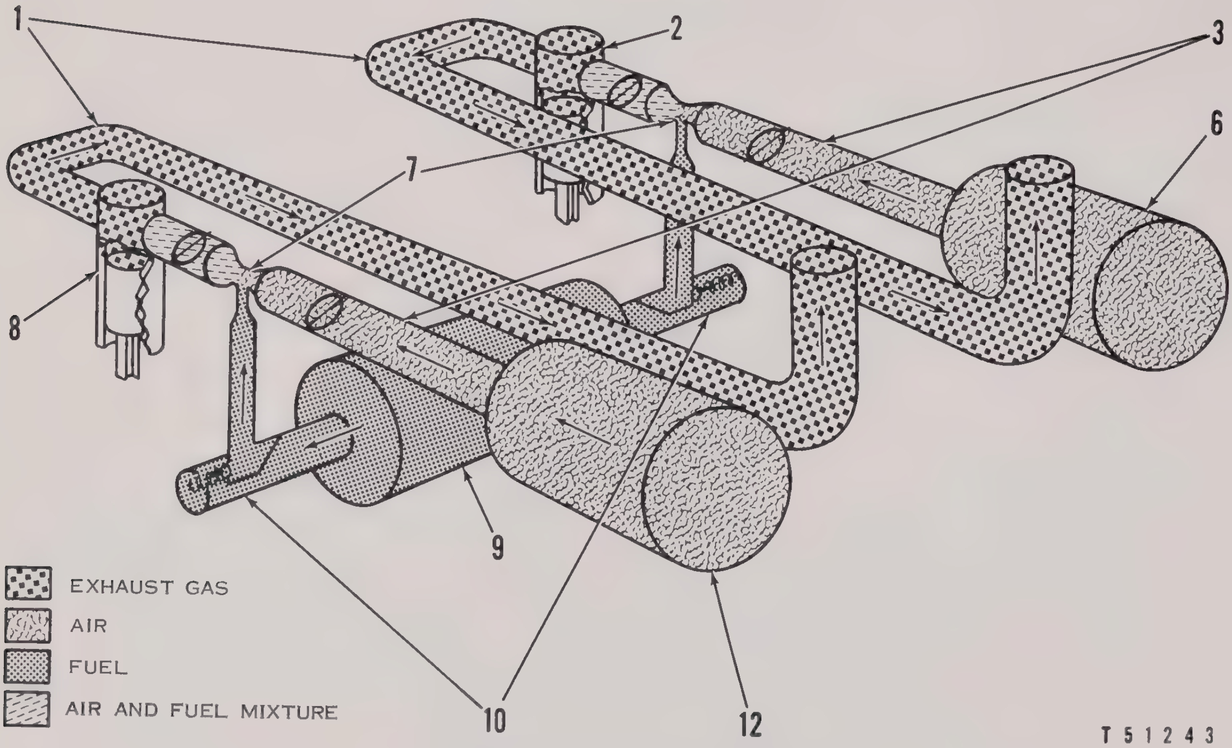
On naturally aspirated engines, air from the air cleaners **(6)** and **(12)** at approximately atmospheric pressure is drawn through the carburetor venturis. Turbocharged engines force air through the carburetor venturis. A smaller diameter at the throat of the venturi increases the air velocity which results in a pressure decrease in the venturi throat. This aids in admitting gas into the air stream.

NOTE

> Fuel gas pressure at the inlet to carburetor regulators **(10)** is always maintained 7 - 10 inches of water (4-6 oz. per square inch) above the pressure of the air entering the carburetor venturis.

As the speed of the engine increases, an increased amount of air is drawn through the venturi, therefore, a greater pressure drop is created and a proportionately greater amount of fuel enters the air stream. The carburetor and carburetor regulator are thus able to maintain approximately a constant mixture ratio between the air and fuel throughout the speed range of the engine. When the engine is operated at reduced load, or slow speed, the throttle discs are almost closed and only a small amount of fuel mixture will enter the cylinders with corresponding low compression and combustion pressures.

Models that are turbocharged and aftercooled incorporate the use of two exhaust gas driven turbo-



AIR INDUCTION AND EXHAUST SYSTEM
(Naturally Aspirated)
(Same nomenclature as previous illustration)

chargers. Energy which ordinarily would be lost from the engine exhaust gases is used to drive the turbochargers.

The engine is cross-blown, that is, the right turbocharger furnishes air to the left cylinder bank **(8)** and the left turbocharger furnishes air to the right cylinder bank **(2)** thus reducing the amount of piping needed to control the flow of air.

As the engine starts, the flow of gases from the engine exhaust manifolds **(1)** is directed to the turbine wheels **(5)** through the vanes on the nozzle. The turbine wheels of the turbochargers are mounted on a common shaft with the impellers **(13)**. The exhaust gases pass over the turbine wheels forcing them and the impellers to rotate. The exhaust gases then pass out of the turbochargers to the exhaust elbow and out the exhaust stack. The exhaust elbow has a cast-in diffuser plate **(4)** in the center which keeps the flow of exhaust gases from the turbochargers separated until they reach the exhaust stack and thus reduce the exhaust back pressure.

As more fuel is added to the air/fuel mixture, more energy is passed on to the exhaust gases. The turbine wheel speed is increased and the impeller speed is increased the same amount to force additional air into the engine cylinders. Speed of the rotating parts also increases when the engine load increases because additional energy is again imparted to the exhaust gases. When the load is reduced, or engine speed changed from high idle to low idle, the exhaust gas energy is reduced and less air passes through the impeller.

A raw water-cooled heat exchanger, known as an aftercooler **(11)**, is installed between the compressor housing and air inlet manifold. Since the air is heated as it passes through the impeller, the aftercooler is used to reduce the compressed air temperature. A lower air temperature makes the air more dense and enables more pounds of air to be packed into the engine cylinders.

Since the power developed depends on the total amount of air/fuel mixture admitted to the engine, turbocharged engines develop greater horsepower than naturally aspirated engines.

A separate fuel system is incorporated in the carburetor to provide the correct mixture for starting. A starting fuel adjustment screw allows for fine adjustment of the starting fuel mixture. An air choke and a gas choke are mounted on a common shaft. The chokes have only two positions, fully open and fully closed. When fully closed, all of the air admitted to the engine flows through an orifice in the air choke disc. The air choke provides a high vacuum to open the main valve in the carburetor regulator and the gas choke closes off the main fuel system during starting.

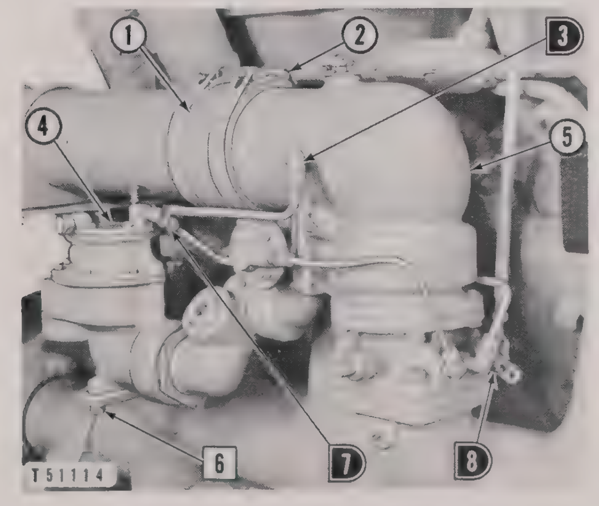
The correct method for stopping the engine is to close the valve in the fuel supply line. The carburetor regulator has a built-in safety feature. The main valve in the regulator is spring loaded to the normally closed position so it is only opened to allow fuel flow when the engine is being started or run. The main valve is opened by a pressure sensing mechanism, connected to the throat of the venturi in the carburetor. With the engine stopped, there is no air flow through the venturi, no pressure drop in the venturi and consequently, the main valve in the carburetor regulator remains closed.

The carburetors and the regulators rarely require attention. If difficulty is being experienced, the carburetors and the regulators can be completely disassembled, washed, and cleaned with compressed air. Inspect all parts carefully and if worn or damaged, replace them with new parts. Diaphragms especially, may become defective because of slight shrinking, even though the appearance is still normal.

CARBURETORS AND CARBURETOR REGULATORS

Removal and Installation

The carburetors and carburetor regulators should be removed individually from the engine.

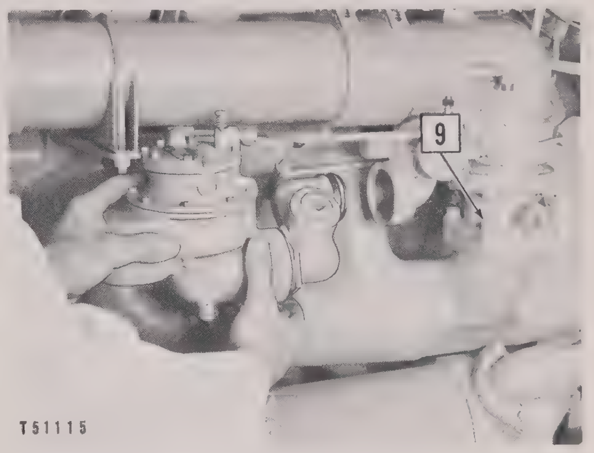


PREPARING TO REMOVE CARBURETOR AND REGULATOR

☐ Remove ◼ Disconnect

1–Hose. 2–Clamp. 3–Pressure balance tube. 4–Regulator. 5–Carburetor. 6–Bolts (two). 7–Balance line. 8–Carburetor control linkage.

1. Shut off the fuel supply.
2. Loosen the clamp **(2)** on the hose **(1)**.
3. Remove the regulator **(4)** as shown.

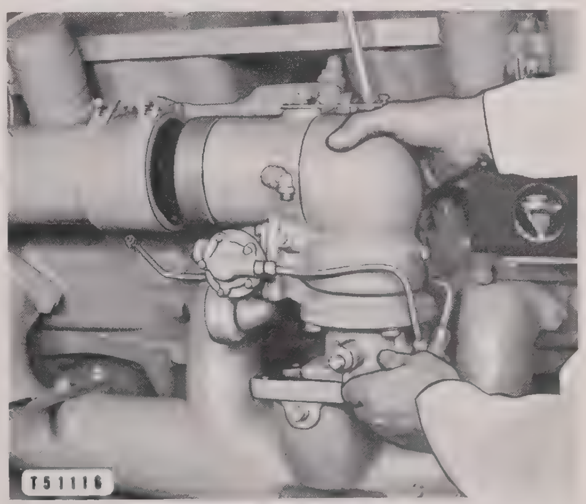


REMOVING THE REGULATOR

☐ Remove

9–Bolts (four).

4. Remove the carburetor **(5)** as shown.



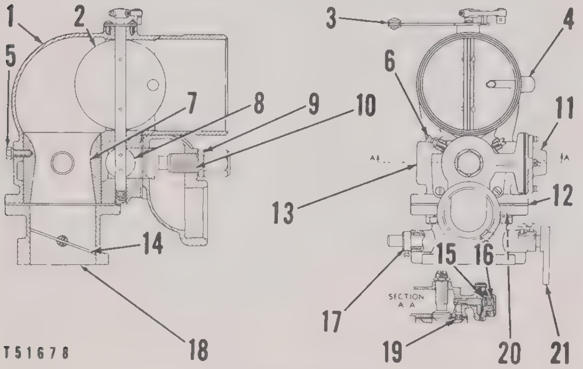
REMOVING CARBURETOR

5. Inspect all gaskets and seals and install in reverse order of removal.

Disassembly and Assembly of Carburetor

1. Remove the four bolts securing the air horn **(1)** to the throttle tube **(18)**.
2. Remove the tube **(20)**.
3. Remove the economizer body **(13)**.

4. Remove the four screws which hold the air choke disc **(2)** and the gas choke disc **(8)** to the choke shaft. Remove the screws which hold the choke wire support assembly **(3)** to the air horn, and remove the choke shaft. Loosen the setscrew and remove the choke lever from the choke shaft.
5. Remove the setscrew **(5)** and the venturi **(7)**.



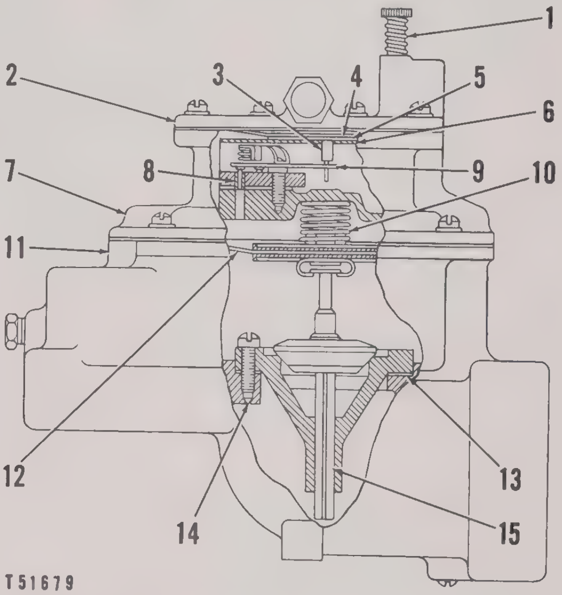
CARBURETOR

1–Air horn.
2–Choke disc.
3–Support assembly.
4–Pitot tube.
5–Setscrew.
6–Starting adjusting screw.
7–Venturi.
8–Choke disc.
9–Locknut.
10–Fuel adjusting screw.
11–Economizer cover.
12–Gasket.
13–Economizer body.
14–Throttle disc.
15–Spring.
16–Economizer diaphragm assembly.
17–Collar.
18–Throttle tube.
19–Economizer orifice.
20–Tube.
21–Throttle lever.

6. Remove the economizer cover **(11)** from the economizer body. This permits the spring **(15)** and diaphragm **(16)** to be removed.
7. Loosen the locknut **(9)** and remove the fuel adjusting screw **(10)** from the elbow.
8. Remove the two screws which secure the throttle disc **(14)** to the throttle shaft. Remove the collar **(17)**, and remove the shaft. Loosen the clamp screw and drive out the spring pin to remove the throttle lever **(21)** from the throttle shaft.
9. The orifice **(19)** can be removed with a screwdriver for inspection, cleaning and replacement, if necessary.
10. Clean and inspect the orifice in the pitot tube **(4)** opening for the balance line.
11. Inspect the gasket **(12)** and diaphragm **(16)** and replace if necessary.
12. Inspect the throttle shaft bearings and adjusting screws **(6)** and **(10)**, and replace if necessary.
13. Adjust the high idle stop screw on the lever **(21)** so that the throttle disc **(14)** is approximately 10° closed from the full open position. This gives the necessary turbulence for full load operation Thoroughly wash all parts and blow out passageways with compressed air. After assembly, complete adjustment of the carburetor as outlined in the topic, ADJUSTMENTS.

Disassembly and Assembly of Regulator

1. Remove the eight screws and remove the bowl cover **(2)** and diaphragm **(4)**.



CARBURETOR REGULATOR

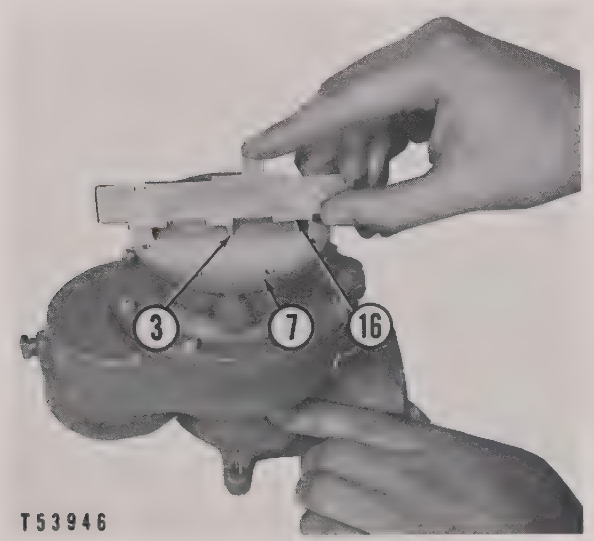
1–Idle adjusting screw.
2–Bowl cover.
3–Push rod.
4–Diaphragm assembly.
5–Locking ring.
6–Partition plate.
7–Bowl.
8–Valve assembly.
9–Lever arm.
10–Diaphragm spring.
11–Body.
12–Diaphragm assembly.
13–Valve seat.
14–Screws (three).
15–Valve assembly.

2. Lift the push rod **(3)** out of the bowl.
3. Remove the locking ring **(5)** and remove the plate **(6)**.
4. Remove the screws retaining the pilot valve assembly and remove the assembly.
5. Remove the screws securing the bowl **(7)** to the body **(11)** and separate the parts. The spring **(10)** and diaphragm are free to be removed. Remove the spring **(10)** and diaphragm assembly **(12)**.
6. Remove the valve assembly **(15)**.
7. Remove the screws **(14)** and remove the valve seat **(13)**.

Thoroughly wash all parts and blow out all passages with compressed air.

Examine the diaphragm and replace if necessary. Check the adjusting screw **(1)**, valve and seat in the valve assembly **(8)** and the valve **(15)** and seat **(13)**, and replace if necessary.

The distance between the top of the push rod **(3)** and the top of the bowl **(7)** is important. This distance can be measured with the Ensign Combination Regulator Gauge No. 8276 **(16)** available through the Ensign Carburetor Co. This is a two position gauge having two steps marked "clear" and "touch." Hold the gauge on edge over the regulator with the edge resting on the bowl, and slide the gauge back and forth over the push rod. When using the step marked "touch," the push rod will move slightly. When the step marked "clear" slides over the push rod, the rod must not move. If an adjustment must be made, bend the lever arm **(9)** slightly by using the slot provided in the gauge. The bend should be made 1/4 inch from the hole in the end of the arm with one finger pressing down on the arm to prevent distortion or injury to the pilot valve and seat.

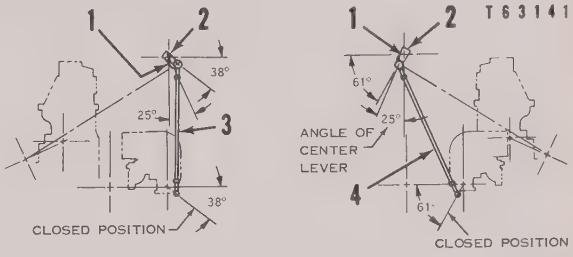


CARBURETOR REGULATOR ADJUSTMENT INSPECTION
3–Push rod. 7–Bowl. 16–Ensign combination regulator gauge No. 8276.

Inspect the plates on the diaphragm **(4)**. If the plates are bowed, straighten or replace them before installing. Bowed plates will limit the upward movement of the diaphragm. Install the diaphragm **(4)**, marked "This Side Up," with plate fastening ears down.

CARBURETOR CONTROL LINKAGE ADJUSTMENT

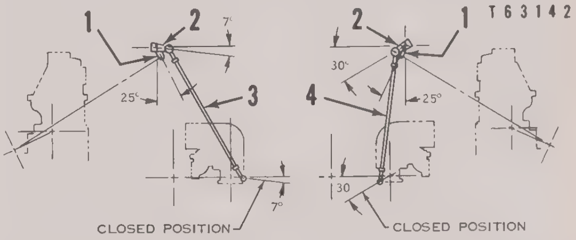
Mechanical Governor



RIGHT SIDE VIEW OF G379 ENGINE WITH MECHANICAL GOVERNOR

LEFT SIDE VIEW OF G379 ENGINE WITH MECHANICAL GOVERNOR

CARBURETOR CONTROL LINKAGE ADJUSTMENTS (G379)
1–Center lever. 2–Lever (two). 3–Rod. 4–Rod.



RIGHT SIDE VIEW OF G398 ENGINE WITH MECHANICAL GOVERNOR

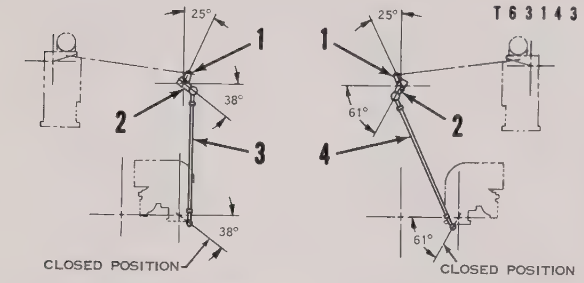
LEFT SIDE VIEW OF G398 ENGINE WITH MECHANICAL GOVERNOR

CARBURETOR CONTROL LINKAGE ADJUSTMENTS (G398)
1–Center lever. 2–Lever (two). 3–Rod. 4–Rod.

1. Position center lever **(1)** on cross shaft assembly at 25° angle as shown.
2. Assemble levers **(2)** to cross shaft assembly at angles shown.
3. Adjust and assemble rods **(3)** and **(4)** with both carburetor throttle plates in CLOSED position and all levers at angles shown.
4. Open throttle plates to approximate IDLE setting. This will change angle of center lever **(1)** on cross shaft assembly from 25° to approximately 30°.
5. With governor at SHUTOFF position, adjust and assemble rod from governor to center lever **(1)**. See topic, GOVERNOR LINKAGE ADJUSTMENTS.

Woodward Governor

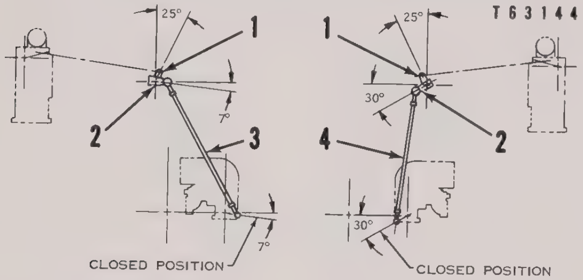
1. Position center lever **(1)** on cross shaft assembly at 25° angle.
2. Assemble levers **(2)** to cross shaft assembly at angles shown.
3. Adjust and assemble rods **(3)** and **(4)** with both carburetor throttle plates in CLOSED position and all levers at angles shown.



RIGHT SIDE VIEW OF G379 ENGINE WITH WOODWARD GOVERNOR

LEFT SIDE VIEW OF G379 ENGINE WITH WOODWARD GOVERNOR

CARBURETOR CONTROL LINKAGE ADJUSTMENTS (G379)
1–Center lever. 2–Lever (two). 3–Rod. 4–Rod.



RIGHT SIDE VIEW OF G398 ENGINE WITH WOODWARD GOVERNOR

LEFT SIDE VIEW OF G398 ENGINE WITH WOODWARD GOVERNOR

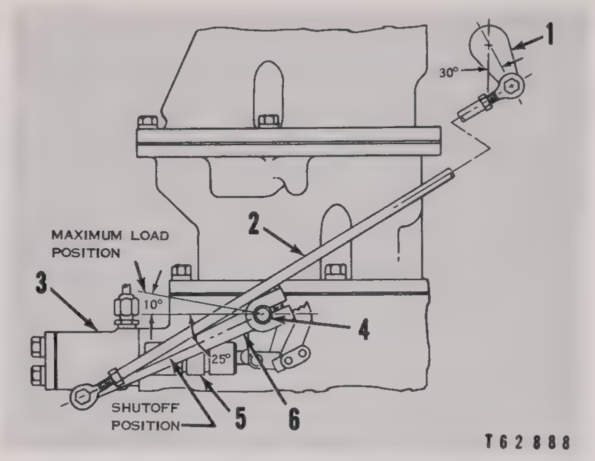
CARBURETOR CONTROL LINKAGE ADJUSTMENTS (G398)
1–Center lever. 2–Lever (two). 3–Rod. 4–Rod.

4. Open throttle plates to approximate LOW IDLE setting. This will change angle of center lever **(1)** on cross shaft assembly from 25° to approximately 20°.
5. With governor at SHUTOFF position, adjust and assemble rod from governor to center lever **(1)**. See topic, GOVERNOR LINKAGE ADJUSTMENTS.

GOVERNOR LINKAGE ADJUSTMENTS

Linkage Adjustment (Mechanical Governor)

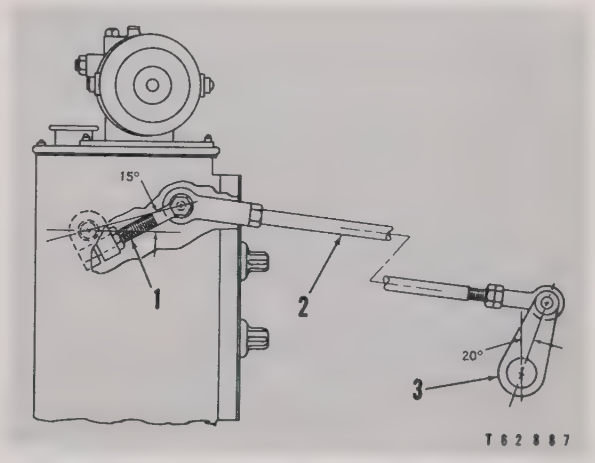
1. Assemble lever **(6)** to shaft assembly **(4)** as follows:
   a. Rotate shaft assembly **(4)** clockwise until piston assembly **(5)** comes flush with outside face of housing [oil pressure override device **(3)** removed].
   b. Assemble lever **(6)** to shaft at 10° above horizontal (MAXIMUM LOAD position).
2. Assemble rod **(2)** from lever **(6)** to control shaft lever **(1)** as follows:
   a. Rotate shaft **(4)** so lever **(6)** is positioned 25° below horizontal (governor SHUTOFF position), as shown.



GOVERNOR CONTROL LINKAGE ADJUSTMENT
(Right Side View of Governor)
1–Control shaft lever. 2–Rod. 3–Oil pressure override device. 4–Shaft assembly. 5–Piston assembly. 6–Lever.

   b. Adjust length and assemble rod **(2)** with lever **(6)** at 25° angle and control shaft lever **(1)** at 30° angle as shown.
3. Make necessary carburetor and carburetor regulator adjustments. See covering topic.

Linkage Adjustment (Woodward Governor)



GOVERNOR CONTROL LINKAGE ADJUSTMENT
1–Lever. 2–Rod. 3–Control shaft lever.

1. Adjust carburetor control linkage.
2. With control shaft lever **(3)** at 20° angle (carburetor throttle plates at LOW IDLE position), as shown, adjust and install rod **(2)** so governor is at SHUTOFF and lever **(1)** in position shown.
3. Make necessary carburetor and carburetor regulator adjustments. See covering topic.

Carburetor and Regulator Adjustments

The following adjustments need be made only when starting an engine for the first time after reconditioning the carburetors or regulators, or when changing to a different grade of fuel.

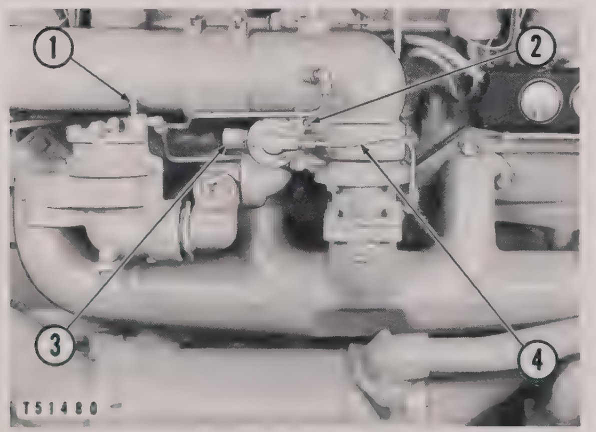
Since the heating value of gaseous fuels varies in different localities, the number of turns given for opening the adjustment screws is only approximate.

Pre-starting Adjustments:

1. Set the starting gas adjustment screw **(2)** on the carburetors four full turns open when natural gas is to be used.
2. Set the main gas adjusting screw **(3)** on the carburetors seven and one-half full turns open when natural gas is to be used.
3. Set the idle adjustment screw **(1)** on the regulators one and one-half turns open when natural gas is to be used.
4. Pull the choke control out to the full choke position.
5. Move the governor control lever to a half speed position.
6. Start the engine.

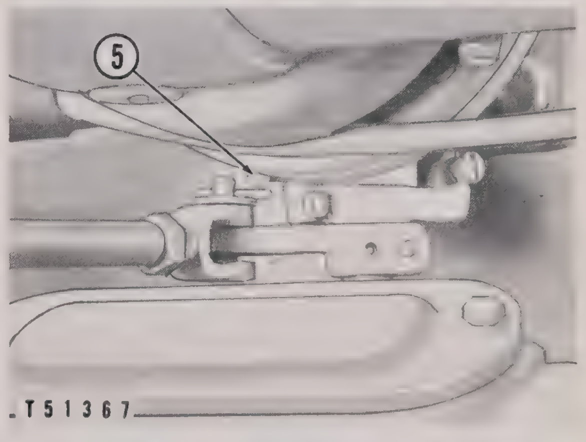
After-starting Adjustments:

1. With the engine running at approximately one-half full load speed, adjust the starting gas adjustment screw **(2)** on the carburetors. First, adjust for maximum engine speed and then turn the screw **(2)** out (richer mixture) until the engine speed drops slightly. Tighten the locknut.



CARBURETOR AND REGULATOR ADJUSTMENTS
1–Idle adjustment screw. 2–Starting gas adjustment screw. 3–Main gas adjustment screw. 4–Line.

2. Push the choke control all the way in. The choke is open in this position.
3. Increase engine speed to approximately two-thirds full load speed and make a temporary adjustment by turning the main gas adjustment screw **(3)**, either direction, until maximum engine speed is obtained.
   a. Equalize inlet manifold vacuum to within .3 inch of mercury. A 36 inch mercury manometer should be used for this adjustment. Operate the engine at full load speed and close the idle adjustment screws on the regulators. To make the adjustment, change the length of the individual governor-to-throttle linkages as outlined in the topic, THROTTLE VALVE SYNCHRONIZATION. Make certain both choke discs are in the wide open position before making any adjustments.
4. Idle adjustment:
   a. After the engine is warm, set the low idle throttle-stop screw **(5)** on each carburetor for the best idle speed. (Recommended idle speed 450 RPM).
   b. Adjust the idle adjustment screw **(1)** on each regulator for the highest idle speed, then readjust throttle-stop screw.



CARBURETOR AND REGULATOR ADJUSTMENTS
5–Low idle throttle-stop adjustment screw.

   c. Repeat steps a and b to obtain an even idle speed.

Variation in manifold vacuum should not exceed .5 inch of mercury at idle speed. Do not correct manifold vacuum at idle by varying the throttle linkage, as this would disturb the setting already obtained. Use only the idle adjustment screw **(1)**.

NOTE

No low idle adjustment is necessary when a Woodward governor is used. Close the idle adjustment screws or remove the tube from the regulator and carburetor and plug the holes with 1/8″ pipe plugs.

5. Final main gas adjustment (with load):
   a. In order to set the main gas adjustment screw, each carburetor must be set independently of the other. Disconnect the linkage to the throttle of the carburetor not undergoing adjustments.

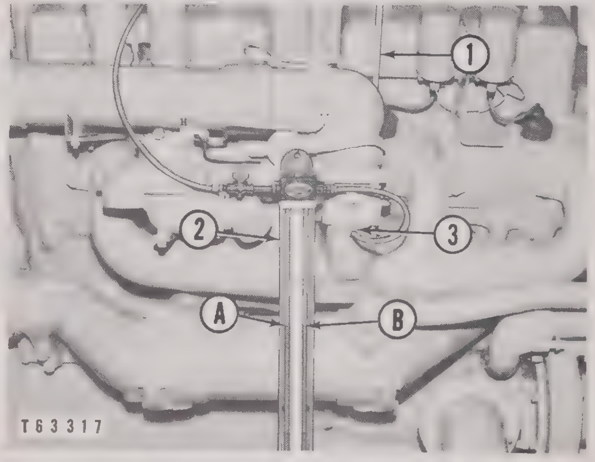
CAUTION

Make sure that the throttle is disconnected and is securely held against the low idle stop.

   b. Open the throttle on the carburetor being adjusted to approximately the one-half full load position, and block or lock the throttle control shaft to keep it from turning and simultaneously load the engine to achieve a constant engine speed between 900 and 1200 RPM. Hold the load constant while making the adjustment and make sure there is no governor action. (The governor must not be able to change engine speed while making the adjustment.)
   c. Turn the main gas adjustment screw **(3)** in either direction until maximum speed is obtained, then turn screw **(3)** in (leaner mixture) until the engine speed drops 10 to 20 RPM. Tighten the locknut.
   d. Release the throttle valve control rod; it should now be free to turn. (Connect any linkage that has been disconnected.)
   e. Adjust the main gas adjustment screw on the other carburetor in a similar manner.
   f. Recheck the idle adjustment.
6. Alternate final main gas adjustment (engine unloaded):
   a. Operate the engine at low idle speed and carefully set the idle adjustment as it affects the mixture under no load conditions.
   b. Disconnect the linkage to the throttle of the carburetor not undergoing adjustments, and make sure the throttle is securely held against the low idle stop.
   c. Disconnect the line **(4)** from the intake manifold to the economizer, and plug the intake manifold connection.
   d. Accelerate the engine to a high speed. Turn main gas adjustment screw out to maximum engine speed and then in until the speed just begins to fall. Set the screw at the point midway between these two points and tighten the locknut. Reinstall line **(4)**.
   e. Adjust the other carburetor in a similar manner.

Throttle Valve Synchronization

Connect one end of mercury manometer **(2)** to connection **(3)** and other end to similar connection on other side of engine.



BALANCING MANIFOLD PRESSURE
1–Rod. 2–Mercury manometer. 3–Connection.
A–Mercury level. B–Mercury level.

Make sure both air choke discs are in FULL OPEN position.

With engine running and governor control lever in TWO-THIRDS SPEED position, adjust length of rod **(1)**. The correct adjustment exists when the mercury level **(A)** in one side of manometer is within 0.3 in. of mercury level **(B)** in other side.

NOTE

Do not vary the main gas adjustment to synchronize inlet manifold pressures. Synchronization is accomplished by linkage adjustment only.

LINE PRESSURE REGULATOR

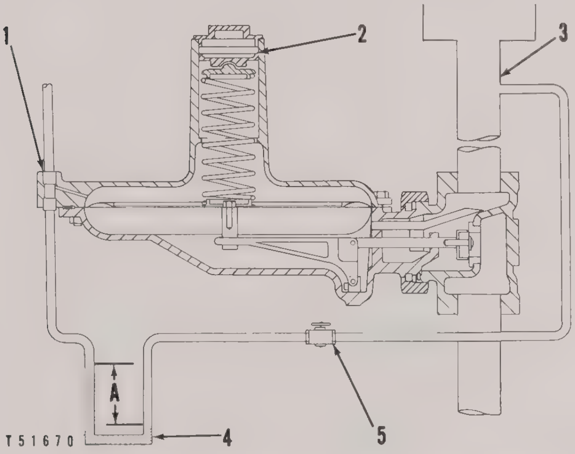
If the engine is turbocharged, or if the fuel supply pressure is exceptionally high, then a line pressure regulator will be required for each carburetor regulator.

The line pressure regulator should be installed in the supply line between the supply source and the carburetor regulator.

Adjustment

1. Line pressure regulator adjustment can be checked with a water manometer. Each line pressure regulator must be adjusted independently of the other.

2. Attach one end of a water manometer **(4)** to the gas inlet of the carburetor regulator **(3)**. On turbocharged engines, attach the other end of the manometer to the bottom port **(1)** of the line pressure regulator as shown, to measure the pressure differential **(A)**. On naturally aspirated engines, attach the manometer only at **(3)** and leave the other end open to the atmosphere.



CHECKING LINE PRESSURE REGULATOR ADJUSTMENT
(Schematic diagram for turbocharged engine)
A–Pressure differential. 1–Bottom port. 2–Adjustment screw. 3–Carburetor regulator. 4–Water manometer. 5–Valve.

3. Remove the cap and turn screw **(3)** until the value **(A)** is within the range listed in the topic, SPECIFICATIONS.

NOTE

The valve **(5)** should be closed before the engine is stopped. This will prevent the manometer fluid from being drawn into the inlet of the carburetor regulator **(3)**.

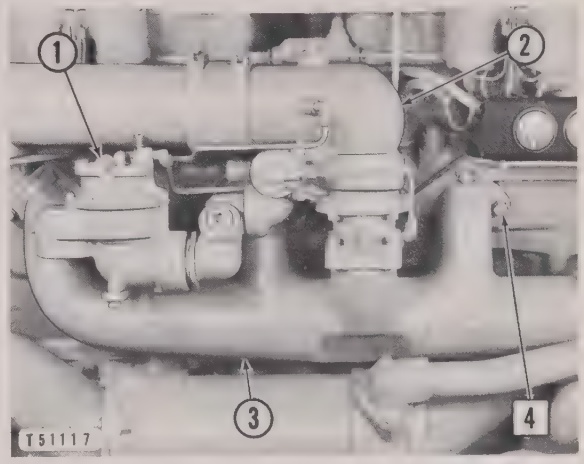
INLET MANIFOLDS

The two inlet manifolds are located on the sides of the engine.

Removal and Installation

Remove the regulator **(1)** and carburetor **(2)** as described in the covering topic.

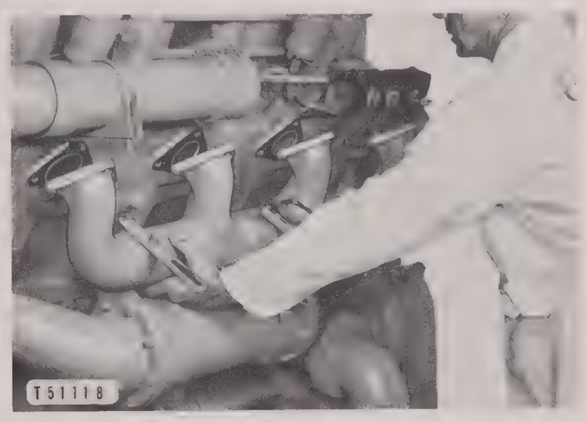
Lift the inlet manifold **(3)** off the engine as shown



PREPARING TO REMOVE THE INLET MANIFOLD

☐ **Remove**

1–Regulator. 2–Carburetor. 3–Inlet manifold. 4–Bolts (three per port).



REMOVING INLET MANIFOLD

Inspect gaskets and replace if damaged. Install in reverse order of removal.

EXHAUST MANIFOLDS

The two water-cooled manifolds are located in the V of the engine and are bolted to the cylinder heads.

Removal and Installation

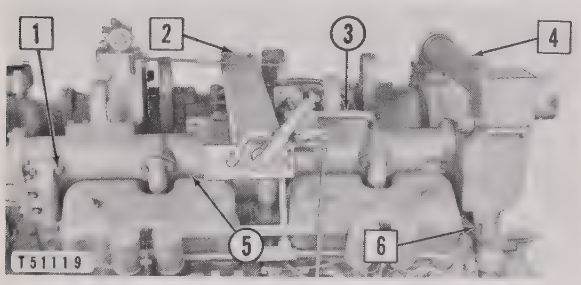
1. Drain the coolant from the engine.

2. Disconnect the exhaust pipe or pipes.

NOTE

If the engine is turbocharged, remove the air cleaners, air cleaner piping, and turbochargers as described in the covering topics. Disconnect the aftercooler vent line.

3. Remove the magneto which is next to the manifold being removed. Tag all wires to assure correct installation.



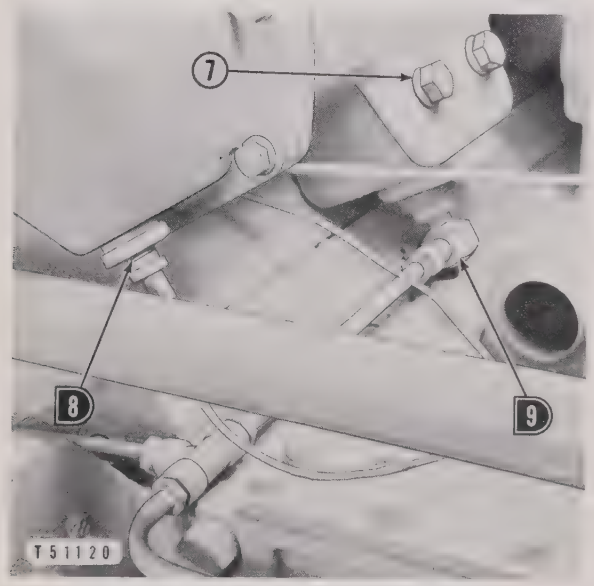
PREPARING TO REMOVE EXHAUST MANIFOLD

☐ Remove

1–Bolts (two per connection). 2–Governor and carburetor control brackets. 3–Conduit. 4–Pipe. 5–Exhaust manifold. 6–Bolts (two).

4. Remove the clip which holds the conduit **(3)** to the exhaust manifold and position the conduit clear of the exhaust manifold.

5. Attach a hoist to the exhaust manifold **(5)**.



DISCONNECTING WATER TEMPERATURE INDICATOR BULB

◗ Disconnect

7–Bolts (four per cylinder). 8–Water temperature indicator bulb. 9–Exhaust manifold water drain tube.

6. Remove the bolts **(7)** which secure the exhaust manifold to the cylinder head.

7. Remove the exhaust manifold as shown.

REMOVING EXHAUST MANIFOLD

8. Install in reverse order of removal replacing all damaged gaskets.

AIR CLEANERS

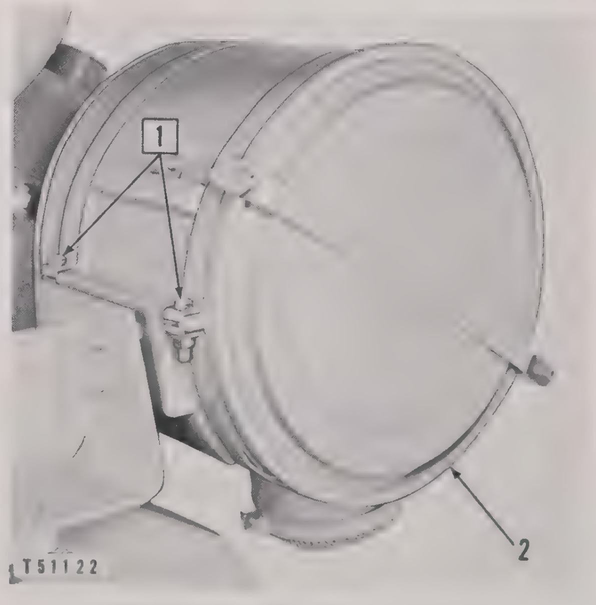
The air cleaners installed on the natural gas engine are the same as the ones used on the diesel engine. On the turbocharged natural gas engine the air cleaners are also in the same location as on the diesel engines. The following instructions apply to the naturally aspirated natural gas engine.

NOTE

See the air cleaner topic in the diesel engine section for air cleaner operation and cleaning instructions.

Removal and Installation

Inspect the O-ring seals at each end of the adapter. Lubricate the O-ring seals with oil and install the air cleaner in reverse order of removal.



PREPARING TO REMOVE AIR CLEANER

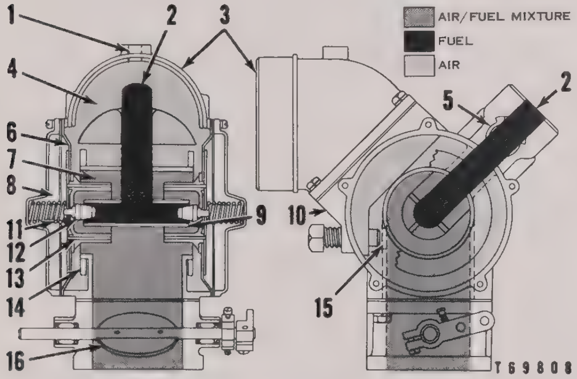
☐ Remove

1–Bolts (two). 2–Air cleaner.

CARBURETOR

Operation

Air enters the carburetor through air horn **(3)** and fills outer chamber **(4)**. Air enters inner chamber **(7)** (mixing chamber) by forcing diaphragm assembly **(6)** away from ring **(14)**. There are two diaphragms, one on each side of the carburetor. Fuel enters the carburetor through fuel inlet **(2)**, past the power mixture adjustment **(5)** to the center of the carburetor and into fuel outlet tube **(9)**. Fuel valve **(12)** is mounted on diaphragm assembly **(6)**. With the diaphragm assembly forced away from ring **(14)**, fuel flows past fuel valve **(12)** and into inner chamber **(7)**. The fuel and air mix in inner chamber **(7)**. This mixture is drawn down past throttle plate **(16)** and into the inlet manifold.



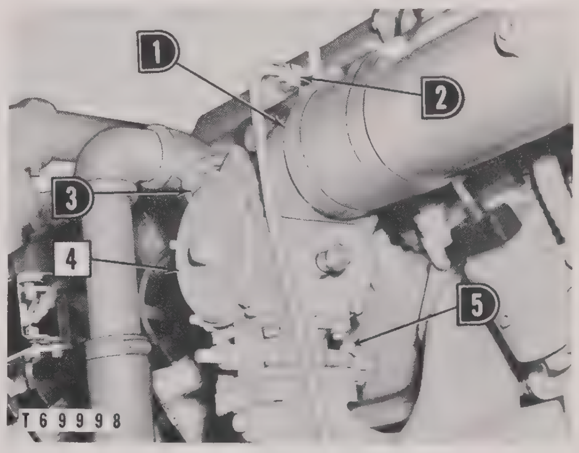
CARBURETOR OPERATION
(Operative position shown)
1–Balance line inlet. 2–Fuel inlet. 3–Air horn. 4–Outer chamber. 5–Power mixture adjustment. 6–Diaphragm assembly (two). 7–Inner chamber. 8–Chamber (two). 9–Fuel outlet tube. 10–Carburetor body. 11–Spring (two). 12–Fuel valve (two). 13–Sensing holes. 14–Ring (two). 15–Idle adjustment opening. 16–Throttle plate.

With the engine stopped, spring **(11)** holds diaphragm assembly **(6)** against ring **(14)** and holds fuel valve **(12)** closed. No air or fuel can flow to inner chamber **(7)**. As the engine is started, the vacuum in the cylinders, created by the intake stroke of the pistons, creates a low pressure situation in inner chamber **(7)**. This low pressure is sensed by chamber **(8)**, behind the diaphragm assembly, through holes **(13)**. This allows the pressure in chamber **(8)** to equalize with the low pressure situation in the inner chamber. The higher inlet pressure acting on the outer portion of the diaphragm assembly overcomes the spring force and moves the diaphragm assembly outward. This also moves fuel valve **(12)** outward and allows air and fuel to flow into the inner chamber. A small volume of air is also metered into the inner chamber through idle adjustment opening **(15)**.

When the engine is operating at a constant RPM, the diaphragms remain in one position. This position is determined by the inlet pressure differential of the gas and air. This pressure differential is maintained by a balance line from the line pressure regulator to the carburetor balance line inlet **(1)**. The pressure differential to the carburetor can be varied by adjusting the line pressure regulator. See the topic, LINE PRESSURE REGULATOR.

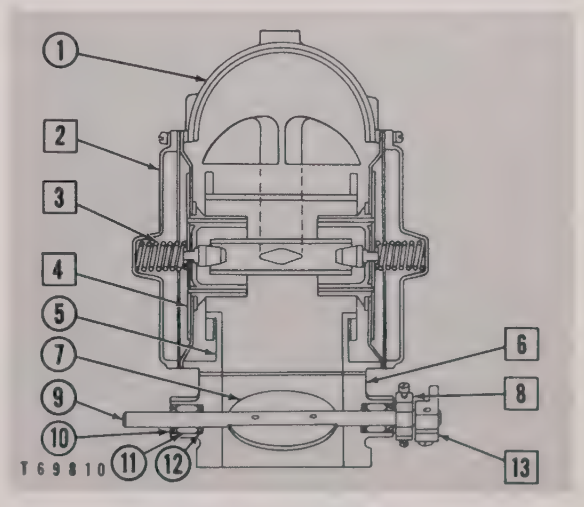
Removal and Installation

Shut off the fuel supply to the carburetor.



REMOVING CARBURETOR
1–Air inlet hose. 2–Balance line. 3–Fuel inlet line. 4–Carburetor. 5–Linkage.

Disassembly and Assembly

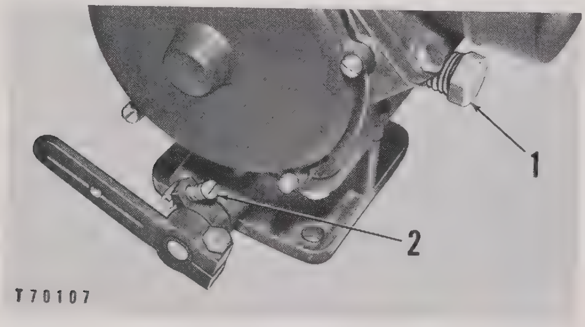


CARBURETOR DISASSEMBLY
1–Air horn. 2–Cover (two). 3–Spring (two). 4–Diaphragm assembly (two). 5–Body assembly. 6–Throttle body assembly. 7–Throttle plate. 8–Lever. 9–Throttle shaft. 10–Seals (two). 11–Bearings (two). 12–Retainer (two). 13–Lever assembly.

1. Remove air horn **(1)** from body assembly **(5)**.
2. Remove idle adjusting screw and spring from body assembly.
3. Remove the screws which secure throttle plate **(7)** to shaft **(9)** and remove shaft. Inspect bearings **(11)**, seals **(10)**, and retainers **(12)**.
4. If installing a new throttle assembly, shaft or lever, pin the lever and shaft together. See the topic, CARBURETOR CONTROL LINKAGE ADJUSTMENT, for correct pinning angle. Drill a .125" dia. hole and through ream for a 2/0 x 1" taper pin.

Adjustments

Turn the power adjustment to center between "R" (rich) and "L" (lean). Fuel mixture adjustments are made by changing the gas pressure from the line pressure regulator. See the topic, LINE PRESSURE REGULATOR.



CARBURETOR ADJUSTMENTS
(Carburetor removed for better illustration)
1–Idle adjustment screw. 2–Throttle stop screw.

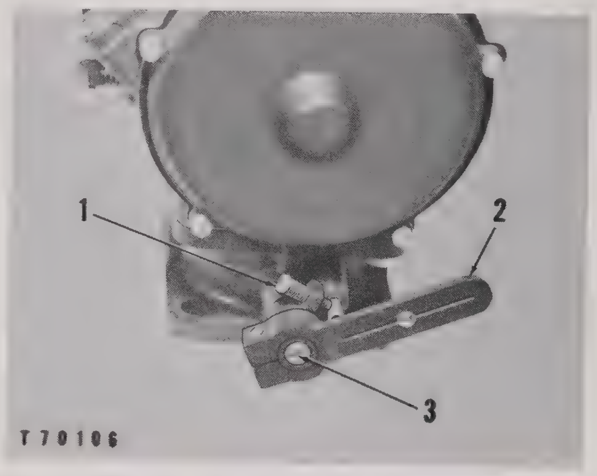
Turn idle adjustment screw **(1)** four full turns open (from the closed position).

Turn throttle stop screw **(2)**, to obtain desired idle speed. Recommended low idle is 425 RPM. (750-800 RPM when used with an electric set).

Throttle Valve Synchronization (Engine not operating)

If the throttle valves are not opening simultaneously on both carburetors, the load will not be balanced between the left and right banks of the engine, and uneven operation can result.

1. Disconnect governor linkages at each throttle shaft lever **(2)**.
2. Turn the low idle throttle stop screw **(1)** out until each throttle will close without allowing the screw to touch the stop. Slots **(3)** cut in the end of the throttle shaft indicate the position of the throttle plate.
3. Adjust each low idle throttle stop screw **(1)** so it will just touch the stop with the throttle plate remaining closed. Throttle shaft lever **(2)** must be in the same relative angular position to the throttle plate [slot **(3)**] on both carburetors.



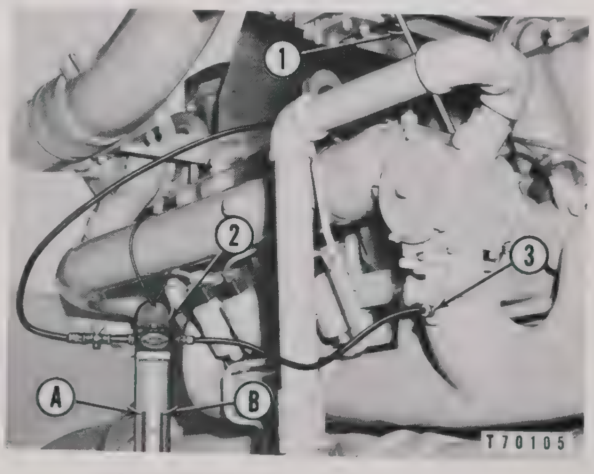
THROTTLE VALVE SYNCHRONIZATION
(Carburetor removed for better illustration)
1–Low idle throttle stop screw. 2–Throttle shaft lever.
3–Slot.

4. Move the governor control lever to the OFF position.
5. Adjust the length of the governor-to-carburetor linkages so both connections can be made with the throttle plates completely closed, and the governor weights fully closed.
6. Connect both linkages to throttle shaft levers **(2)**.
7. Set both low idle throttle stop screws **(1)** for the recommended low idle.

Throttle Valve Synchronization (Engine operating)

Check that the regulators are maintaining the required pressure for the fuel being used and that the pressures are equal to both carburetors.

Connect one end of mercury manometer **(2)** to connection **(3)** and the other end to the similar connection on the other side of the engine.



BALANCING MANIFOLD PRESSURE
1–Rod. 2–Mercury manometer. 3–Connection.
A–Mercury level. B–Mercury level.

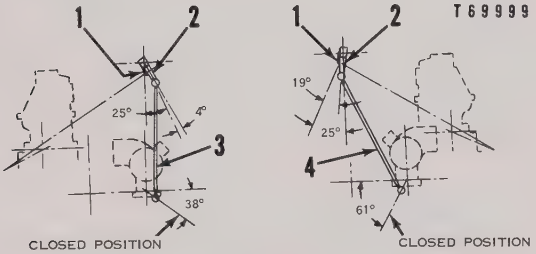
With the engine operating and governor control lever in TWO-THIRDS SPEED position, adjust length of rod **(1)**. The correct adjustment exists when mercury level **(A)** in one side of the manometer is within 0.3 in. of mercury level **(B)** in the other side.

NOTE

Do not vary the regulator adjustment to synchronize the inlet manifold pressures. Synchronization is accomplished by linkage adjustment only.

CARBURETOR CONTROL LINKAGE ADJUSTMENTS

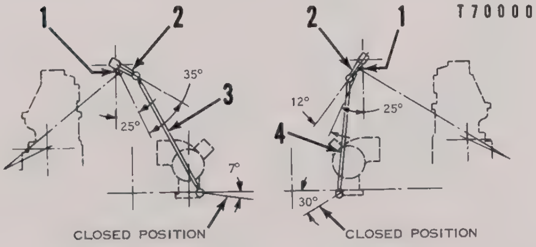
Mechanical Governor



RIGHT SIDE VIEW OF G379 ENGINE WITH MECHANICAL GOVERNOR

LEFT SIDE VIEW OF G379 ENGINE WITH MECHANICAL GOVERNOR

G379 CARBURETOR CONTROL LINKAGE ADJUSTMENT
1–Center lever. 2–End levers (two).
3–Rod. 4–Rod.



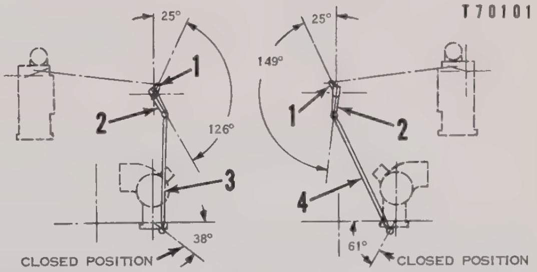
RIGHT SIDE VIEW OF G398 ENGINE WITH MECHANICAL GOVERNOR

LEFT SIDE VIEW OF G398 ENGINE WITH MECHANICAL GOVERNOR

G398 CARBURETOR CONTROL LINKAGE ADJUSTMENT
1–Center lever. 2–End levers (two).
3–Rod. 4–Rod.

1. Assemble levers **(2)** to cross shaft assembly at angles shown from center lever **(1)**.
2. Position center lever at 25° angle. Adjust and assemble rods **(3)** and **(4)** with both throttle plates in the CLOSED position and all levers at angles shown.
3. Open throttle plates to approximate idle setting. This will change angle of center lever **(1)** from 25° to approximately 29°.
4. With governor at SHUTOFF position, adjust and assemble the rod from center lever **(1)** to the governor. See the topic, GOVERNOR LINKAGE ADJUSTMENT.

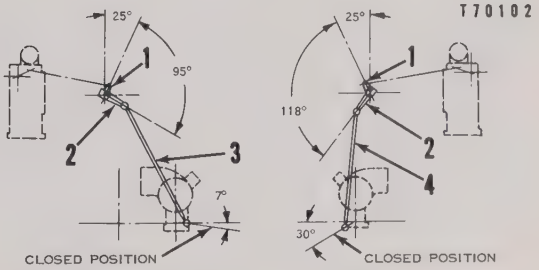
Woodward Governor



RIGHT SIDE VIEW OF G379 ENGINE WITH WOODWARD GOVERNOR

LEFT SIDE VIEW OF G379 ENGINE WITH WOODWARD GOVERNOR

G379 CARBURETOR CONTROL LINKAGE ADJUSTMENTS
1–Center lever. 2–End levers (two).
3–Rod. 4–Rod.



RIGHT SIDE VIEW OF G398 ENGINE WITH WOODWARD GOVERNOR

LEFT SIDE VIEW OF G398 ENGINE WITH WOODWARD GOVERNOR

G398 CARBURETOR CONTROL LINKAGE ADJUSTMENTS
1–Center lever. 2–End levers (two).
3–Rod. 4–Rod.

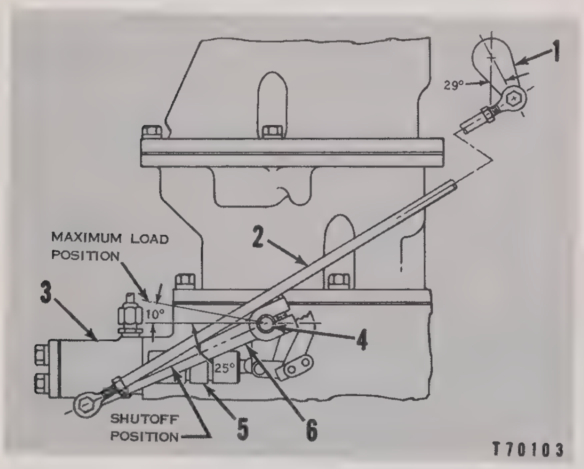
1. Assemble levers **(2)** to cross shaft assembly at angles shown from center lever **(1)**.
2. Position center lever at 25° angle. Adjust and assemble rods **(3)** and **(4)** with both throttle plates in the CLOSED position and all levers at angles shown.
3. Open throttle plates to approximately idle setting. This will change angle of center lever **(1)** from 25° to approximately 21°.
4. With governor in SHUTOFF position, adjust and assemble the rod from center lever **(1)** to the governor. See topic, GOVERNOR LINKAGE ADJUSTMENT.

GOVERNOR LINKAGE ADJUSTMENTS

Linkage Adjustment (Mechanical Governor)

1. Assemble lever **(6)** to shaft assembly **(4)** as follows:
   a. Rotate shaft assembly **(4)** clockwise until piston assembly **(5)** comes flush with outside face of housing [oil pressure override device **(3)** removed].
   b. Assemble lever **(6)** to shaft at 10° above horizontal (MAXIMUM LOAD position)

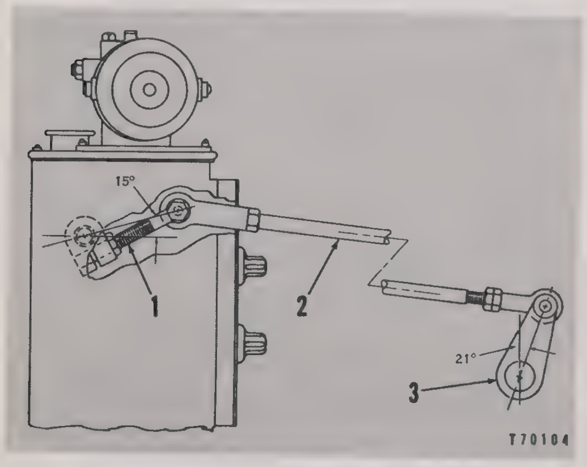
2. Assemble rod **(2)** from lever **(6)** to control shaft lever **(1)** as follows:
   a. Rotate shaft **(4)** so lever **(6)** is positioned 25° below horizontal (governor SHUTOFF position), as shown.
   b. Adjust length and assemble rod **(2)** with lever **(6)** at 25° angle and control shaft lever **(1)** at 29° angle as shown.



GOVERNOR CONTROL LINKAGE ADJUSTMENT
(Right Side View of Governor)
1–Control shaft lever. 2–Rod. 3–Oil pressure override device. 4–Shaft assembly. 5–Piston assembly. 6–Lever.

3. Make necessary carburetor and carburetor regulator adjustments. See covering topic.

Linkage Adjustment (Woodward Governor)



GOVERNOR CONTROL LINKAGE ADJUSTMENT
1–Lever. 2–Rod. 3–Control shaft lever.

1. Adjust carburetor control linkage.
2. With control shaft lever **(3)** at 21° angle (carburetor throttle plates at LOW IDLE position), as shown, adjust and install rod **(2)** so governor is at SHUTOFF and lever **(1)** in position shown.
3. Make necessary carburetor and carburetor regulator adjustments. See covering topic.

LINE PRESSURE REGULATOR

A line pressure regulator is required to maintain a constant inlet pressure differential between the gas and air to the carburetor. The pressure differential will vary according to the BTU rating of the gas being used.

Turbocharged and aftercooled engines require a regulator. In addition, naturally aspirated engines with a gas supply pressure exceeding the desired pressure differential to the carburetor must use a regulator.

Adjustment

Make the line pressure regulator adjustment using a water manometer, while the engine is operating.

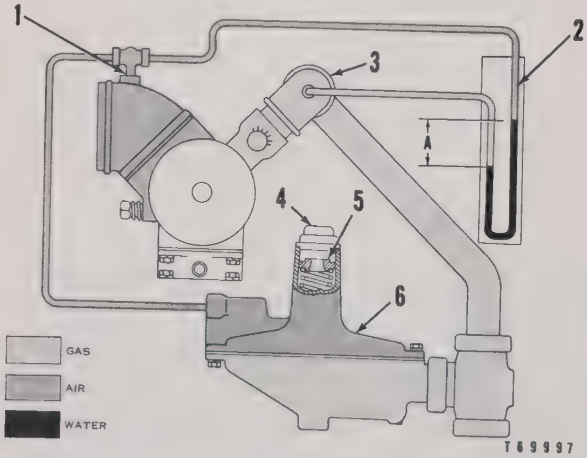
Connect water manometer **(2)** between balance line inlet **(1)** and fitting elbow **(3)**.

NOTE

If a tee is not present at balance line inlet **(1)**, install a tee for use in adjusting gas pressure.

CAUTION

On earlier S201 Regulators, with hole in adjusting screw **(5)**, engine must be operating under no load at idle speed before removing cap **(4)**.

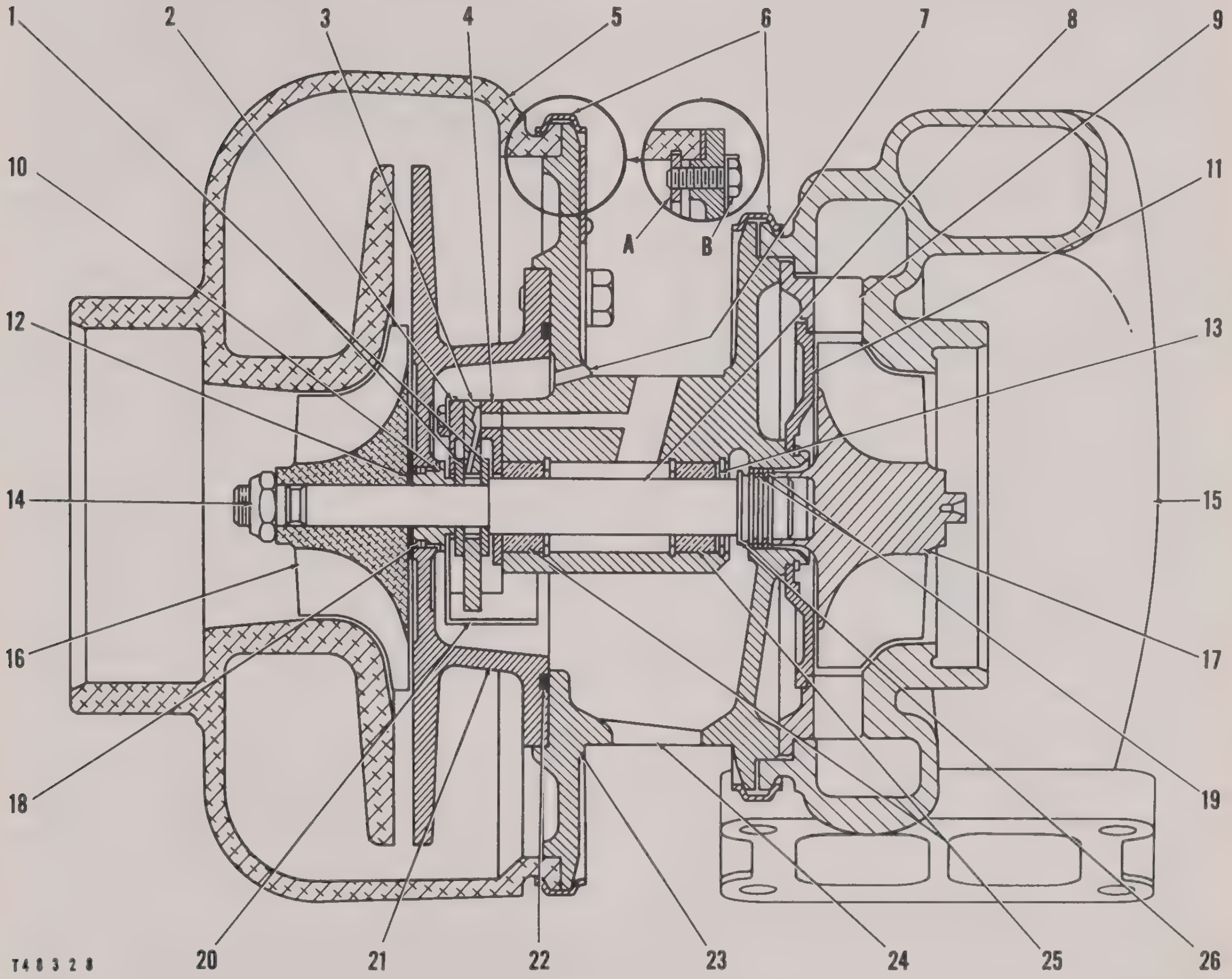


ADJUSTING LINE PRESSURE REGULATOR
1–Balance line inlet. 2–Water manometer. 3–Elbow. 4–Cap. 5–Adjusting screw. 6–Line pressure regulator. A–Pressure differential to be adjusted.

Remove cap **(4)** on line pressure regulator **(6)** and turn adjusting screw **(5)** until pressure differential **(A)** is 5½″ of water (when using 1000 BTU natural gas). In G379 applications which use a line pressure regulator and compensator (mounted above carburetor in balance line), pressure differential **(A)** will increase, after adjustment, to 8″ of water when operating at full load.

Turbocharger

INTRODUCTION



TURBOCHARGER

A–Ring.
B–Bolt.
1–Thrust rings.
2–Retainer.
3–Thrust bearing.
4–Retainer.
5–Compressor cover.
6–Clamps.
7–Oil cavity vent passage.
8–Shaft.
9–Nozzle.
10–Sleeve.
11–Turbine back plate.
12–Shims.
13–Wear washer.
14–Nut.
15–Turbine housing.
16–Compressor impeller.
17–Turbine wheel.
18–Piston ring seals.
19–Piston ring seals.
20–Oil deflector.
21–Compressor back plate.
22–Seal.
23–Bearing housing.
24–Oil drain hole.
25–Bearings.
26–Oil thrower.

The turbocharger is designed to increase the diesel engine power output. The turbocharger absorbs energy from the diesel exhaust gases, and uses this energy to drive the compressor impeller **(16)** for supercharging the diesel engine.

The turbocharger is comprised of a turbine wheel **(17)** and a compressor impeller **(16)** on a rotating shaft **(8)**, a bearing housing **(23)**, a turbine housing **(15)**, compressor cover **(5)**, and a compressor back plate **(21)**.

The turbine wheel is located in the turbine housing and is permanently secured to one end of the shaft. The impeller is secured to the other end of the shaft by a nut **(14)** to form an integral rotating assembly. To assure reliability and freedom from vibration, all parts of the rotating assembly have been carefully dynamically balanced.

The bearing housing **(23)** encloses and supports the rotating assembly and contains the oil inlet hole and oil outlet hole. The turbine housing and compressor cover are mounted to the bearing housing and secured in position by the clamps **(6)**.

NOTE

Some models secure the compressor cover to the bearing housing by means of a ring **(A)** and bolts **(B)** rather than the clamp **(6)**.

A tube, one end of which is connected to the crankcase, is connected to the oil cavity vent passage **(7)**. Venting this area promotes the draining of the oil from the bearing housing, and therefore away from the seals, thus reducing the work-load imposed on the seals.

NOTE

Some earlier engines have a breather connected to the passage **(7)** instead of the vent tube.

The rotating assembly is supported by two full floating pressure lubricated bearings **(25)** located in the bearing housing. Filtered engine oil is supplied to the bearings through passages in the housing in sufficient quantity to lubricate the shaft bearings **(25)** and thrust bearing **(3)**. This oil also aids in the removal of excessive heat. Oil returns from the turbocharger to the crankcase through an external tube at **(24)**. Thrust loads are absorbed by the stationary thrust bearing **(3)** and the rotating thrust rings **(1)**. The oil deflector **(20)** contains and routes the oil thrown from the shaft and thrust rings back to the drain opening **(24)**.

Piston rings **(18)** and **(19)** on either end of the shaft prevent oil from escaping the bearing housing.

The turbine housing, besides housing the turbine wheel, acts as a chamber for the exhaust gases from the diesel engine. The gases are directed through the turbine housing and into contact with the turbine blades by the nozzle **(9)**. Different nozzles are used for different engine applications. For the correct nozzle, see the Rack Setting Charts.

Shims **(12)** are located between the impeller **(16)** and the sleeve **(10)** making it possible to adjust the impeller-to-cover clearance.

The turbocharger is mounted on the exhaust outlet of the diesel engine exhaust manifold. The exhaust gases from the diesel engine pass through the turbine end of the turbocharger before they are discharged into the atmosphere. This flow of exhaust gases through the turbine wheel provides the energy to operate the turbocharger.

During operation, the turbocharger responds to the engine load demands by reacting to the flow of exhaust gases and the corresponding demand of the engine for air.

The exhaust gases enter the turbine housing **(15)** at the exhaust inlet opening and are directed through the vanes of the nozzle **(9)** into contact with the blades of the turbine wheel **(17)**. The exhaust provides the driving force to turn the turbine wheel and the impeller **(16)**.

The turbocharger should always be handled carefully to avoid damage to any of its components.

ALTITUDE OPERATION

The maximum turbocharger speed is determined by the rack setting, the high idle speed setting, the pressure ratio control setting, on engines so equipped, and the altitude at which the engine is operated. The rack setting has been set to permit the engine to be operated at the altitude given on the warning plate on the instrument panel or valve cover. The high idle speed setting is not the same for all altitudes. If the high idle speed or the rack setting is greater than specified for the altitude at which the engine is operated, serious damage to engine or turbocharger parts may result.

The maximum altitude at which the engine can be operated is specified on the altitude warning plate located on the valve cover or instrument panel. The governor housing and turbocharger are sealed to prevent serious engine damage or personal injury due to operation of the engine with incorrect settings or turbocharger nozzle. Changes to the turbocharger, rack setting, or high idle speed should be made only by a Caterpillar dealer serviceman.

The engine can be operated at a lower altitude than specified on the warning plate without danger of engine damage, but with slightly less than maximum performance. When operated at a higher altitude, the rack setting and high idle speed setting must be changed only by a Caterpillar dealer serviceman. After making any changes, the new altitude limit should be stamped on the altitude warning plate.

Also, the new high idle, full load speed, and rack setting should be stamped on the governor warning plate. Reseal the governor housing for continued protection.

SEALING OF THE TURBOCHARGER

The turbocharger is sealed at the factory as shown at **(1)**. Factory installed seals are identified by the letters CT CO. Dealer's sealing tool, 6H4160 Sealing Tool Assembly, will impress the letters DLR on the seals.

TURBOCHARGER FACTORY SEAL
1–Seal.

CHECKING BEARING CLEARANCE

A quick check of bearing condition can be made without disassembling the turbocharger. This can be done by inspecting the compressor impeller, turbine wheel, turbine housing and compressor cover. If there is no indication of either the impeller rubbing the compressor cover or the turbine wheel rubbing the turbine housing, the bearing clearances are generally satisfactory.

A more reliable check of bearing condition can be made only when the turbocharger is disassembled and the bearings, shaft journal and housing bore diameters can actually be measured. See the SPECIFICATIONS for these diameters.

While the turbocharger is disassembled, carefully check the back surfaces of the compressor impeller and turbine wheel for signs of contact with the cover or housing. Contact in these areas would indicate a worn thrust bearing or thrust rings.

CHECKING TURBOCHARGER SHAFT END CLEARANCE

See the SPECIFICATIONS for normal and permissible shaft end clearance (axial movement). End clearance is checked with a dial indicator, either on or off the engine. If permissible clearance is exceeded, recondition the turbocharger.

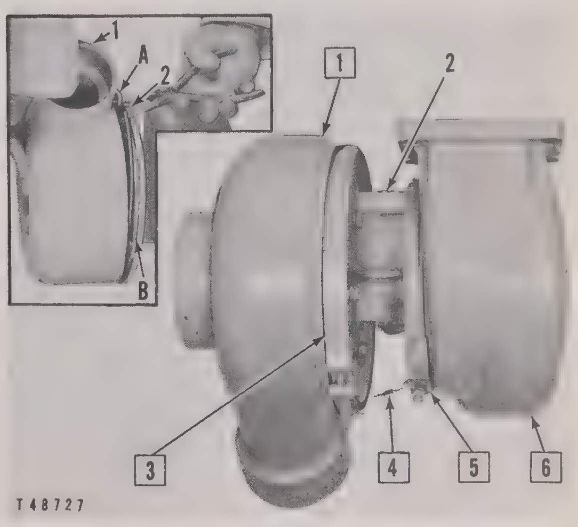
DISASSEMBLY OF THE TURBOCHARGER

Compressor Cover and Turbine Housing Removal and Installation

1. Cover all turbocharger openings and wash the exterior thoroughly with nonflammable fluid before disassembly.
2. Mark compressor cover **(1)**, turbine housing **(6)** and bearing housing **(2)**, prior to disassembly, to insure correct positioning upon assembly.

NOTE

On some models, clamp **(3)** is replaced by ring **(A)** which fits into a groove in compressor cover **(1)** and is secured to bearing housing **(2)** by bolts. It is necessary on these models, to remove the bolts and ring prior to removing the compressor cover. Upon assembly it will also be necessary to cement the side of a new gasket **(B)** to the bearing housing. Tighten the bolts to the torque value in the SPECIFICATIONS.

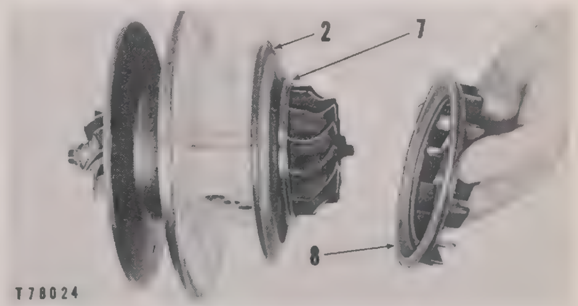


PREPARING TO REMOVE COMPRESSOR COVER AND TURBINE HOUSING
A–Ring. B–Gasket. 1–Compressor cover. 2–Bearing housing. 3–Clamp. 4–Seal. 5–Clamp. 6–Turbine housing.

CAUTION

Use caution when removing the turbine housing. Turbine nozzle **(8)** is a loose fit on turbine back plate **(7)**.

3. Lift nozzle **(8)** from turbine back plate **(7)**.



REMOVING NOZZLE
2–Bearing housing. 7–Turbine back plate. 8–Nozzle.

4. Before installing the compressor cover and turbine housing, see the topic CLEANING AND INSPECTION.
5. Complete the assembly. Turn the impeller by hand to be certain there is no rubbing or binding within the turbocharger.

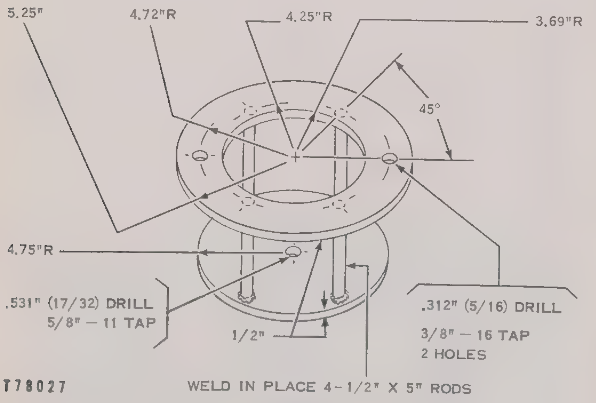
Rotating Parts

Before disassembly of the rotating assembly, measure the shaft end clearance as previously described. If the clearance is excessive, or if either the turbine wheel or impeller has rubbed against the housing or cover, the bearings and/or thrust bearing and thrust rings must be replaced. Bent impeller blades require replacement of the entire rotating assembly. Turbine blades, which are noticeably bent also require replacement of the rotating assembly.

Bearing failure can damage the shaft journals and/or thrust bearing or rings. Excessive wear or roughness renders the shaft unsuitable for reuse. If the shaft journals measure less than the specified diameter, a new rotating assembly should be installed. Visual inspection and experience are the only ways to determine when the roughness of the shaft prohibits reusing the rotating assembly. New bearings will not correct excessive wear on the thrust bearing or thrust rings.

Installing new bearings does not eliminate the necessity of inspecting and cleaning the rotating parts.

1. Assemble fixture adapter **(2)** to fixture **(4)**. Place bearing housing **(1)**, containing the rotating parts, on the fixture adapter with the turbine wheel down as illustrated.


5.25"
4.72"R
4.25"R
3.69"R
45°
4.75"R
.531" (17/32) DRILL
5/8" — 11 TAP
1/2"
.312" (5/16) DRILL
3/8" — 16 TAP
2 HOLES
T78027
WELD IN PLACE 4-1/2" X 5" RODS

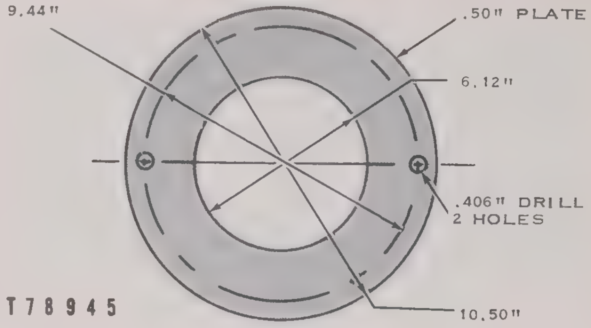
FIXTURE

2. Before removing the impeller, make sure the alignment marks on the impeller and the shaft are visible, since all rotating parts are rematched during reassembly to maintain the previously established dynamic balance of the unit.

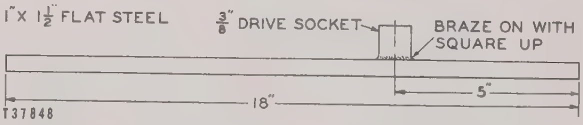
NOTE

Later rotating parts are balanced and no alignment is necessary.

3. Remove the nut. The rotating assembly can be held stationary by using wrench **(3)**.


9.44"
.50" PLATE
6.12"
.406" DRILL
2 HOLES
10.50"
T78945

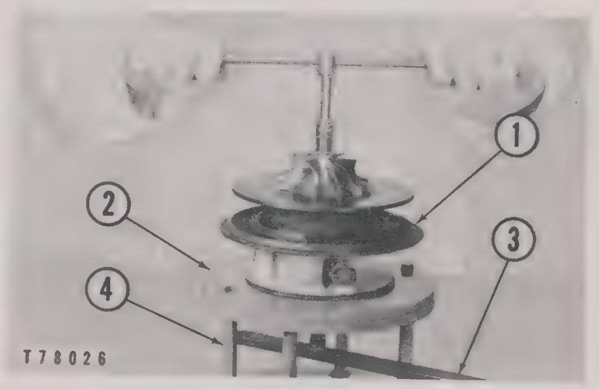
FIXTURE ADAPTER


1" X 1½" FLAT STEEL
⅜" DRIVE SOCKET
BRAZE ON WITH
SQUARE UP
18"
5"
T37848

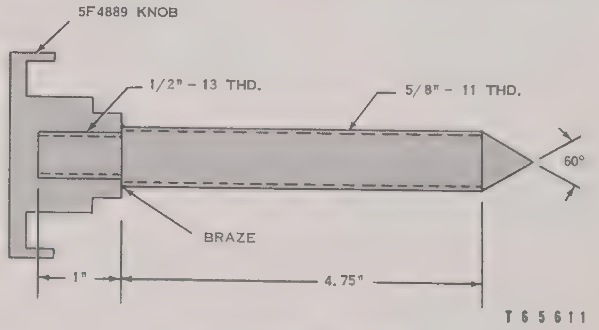
WRENCH

CAUTION

Take care to prevent any distortion of the blades.


1
2
3
4
T78026

REMOVING NUT
1–Bearing housing. 2–Fixture adapter. 3–Wrench. 4–Fixture.

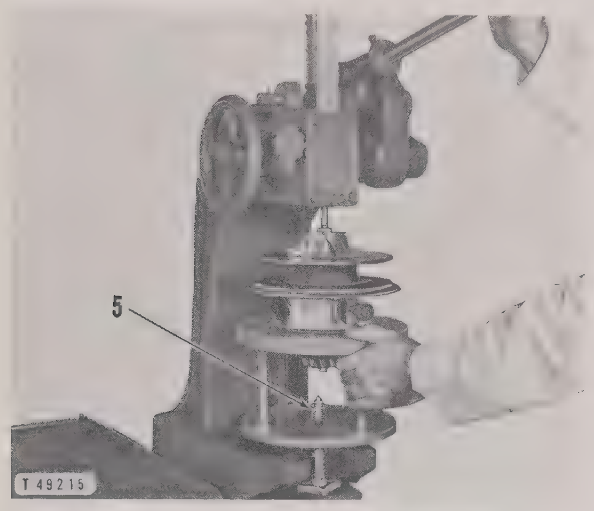

5F4889 KNOB
1/2" - 13 THD.
5/8" - 11 THD.
60°
BRAZE
1"
4.75"
T65611

SUPPORTING SCREW

4. Thread supporting screw **(5)** into the base of the fixture to contain the turbine wheel and shaft when pressed from the impeller. Leave a space between the end of the screw and the

turbine wheel equal to or slightly greater than the thickness of the impeller. This will allow an unobstructed pressing action on the shaft and still prevent the turbine wheel from being damaged by striking against the fixture base.

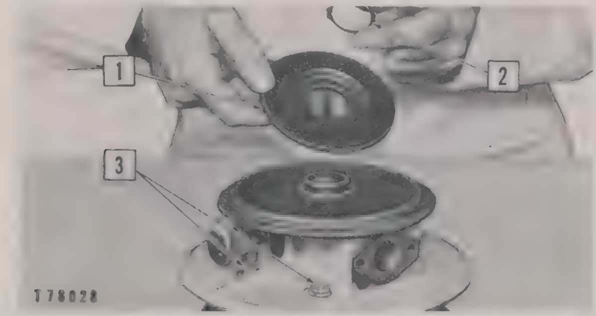
5. Using a press and a pin, press the shaft and turbine wheel from the impeller hub as shown.



PRESSING SHAFT AND TURBINE WHEEL FROM IMPELLER
5–Supporting screw.

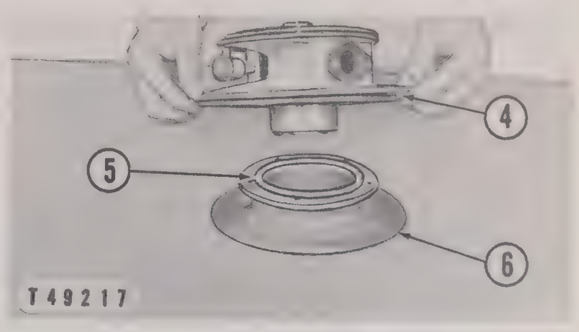
6. Remove the impeller and the shims from beneath the impeller.
7. Back off screw **(5)** and remove bearing housing from the fixture to allow the removal of the turbine wheel and shaft.
8. Measure the shaft journal diameters and inspect the journals for roughness. If the journal diameters are less than specified, the rotating assembly must be replaced. See the SPECIFICATIONS for correct dimensions.
9. Inspect the piston ring-type seals and measure the thickness. Measure the width of the seal grooves. See the SPECIFICATIONS.

Bearing Housing

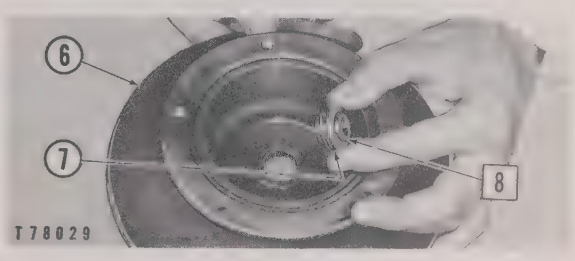


REMOVING TURBINE BACK PLATE
1–Back plate. 2–Snap ring. 3–Bolts (five).

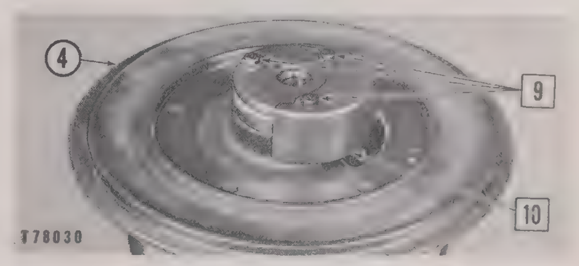
1. Separate bearing housing **(4)** from compressor back plate **(6)** and remove O-ring seal **(5)**.



SEPARATING HOUSING AND PLATE
4–Bearing housing. 5–O-ring seal. 6–Compressor back plate.

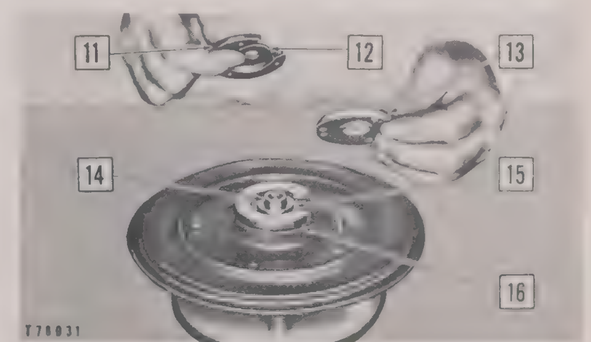


DISASSEMBLING COMPRESSOR BACK PLATE
6–Compressor back plate. 7–Piston ring-type seals. 8–Sleeve.



OIL DEFLECTOR REMOVAL
4–Bearing housing. 9–Bolts. 10–Oil deflector.

2. Inspect piston ring-type seals **(7)** and measure the thickness. Measure the width of the seal groove. See the SPECIFICATIONS.

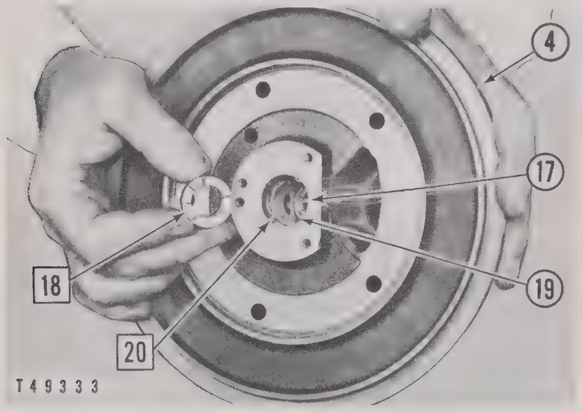


THRUST BEARING REMOVAL
11–Oil retainer. 12–Thrust ring. 13–Thrust bearing. 14–Spacer. 15–Thrust ring. 16–Oil retainer.

3. Remove the outboard snap ring, wear washer, bearing **(17)** and inboard snap ring **(19)** from bearing housing **(4)**.

NOTE

When assembling, position the wear washer between bearing **(17)** and outboard snap ring.



BEARING REMOVAL
4–Bearing housing. 17–Bearing. 18–Bearing. 19–Inboard snap ring. 20–Snap ring.

4. Inspect and measure thrust rings **(12)** and **(15)**, thrust bearing **(13)**, the bore in bearing housing **(4)**, the wear washer and bearings **(17)** and **(18)**. See the SPECIFICATIONS.

NOTE

When bearings **(17)** and **(18)** do not measure up to SPECIFICATIONS, install new bearings. Bearings can be serviceable even though the plating is worn off.

5. Replace any worn or damaged parts.

CLEANING AND INSPECTION

Inspect rotating parts for binding and damage caused by rubbing on adjacent parts. Replace any damaged parts if any of these symptoms are present.

Wash all parts with cleaning solvent and dry thoroughly. Use wood to clean the carbon and deposits from the turbine housing and the nozzle.

The turbine wheel must be cleaned with a good cleaning solvent in order to dissolve the carbon. The amount of soaking depends on the amount and type of deposits on the wheel. When hard carbon deposits are formed, soaking in solvent-type cleaner for an hour or more is required. The loosened particles must all be scraped off with a stiff brush or a specially shaped piece of wood and, if necessary, the whole process repeated. If the wheel is covered with soot only, washing with a stiff brush and cleaning solvent and then rinsing with clean water will be sufficient.

CAUTION

The rotating components must be thoroughly cleaned in order to maintain the critical balance of the unit. Do not use a **wire** brush or wheel.

ASSEMBLING TURBOCHARGER

Before assembling, be certain all parts are thoroughly clean. Extreme care must be taken to keep out dirt and foreign material.

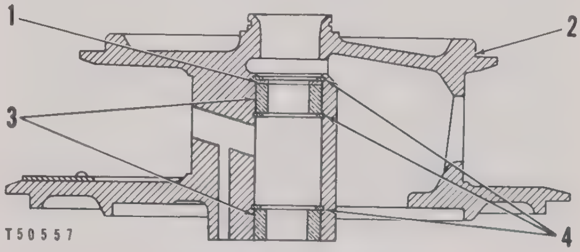
Bearing Housing

Install snap rings **(4)**, wear washer **(1)** and bearings **(3)** in bearing housing **(2)**.

CAUTION

Exercise extreme care during installation of snap rings **(4)** to prevent scratching the bearing housing bore. Each snap ring must be installed with the flat side facing the bearing for which it is acting as a retainer. Lubricate the bearings prior to installation.

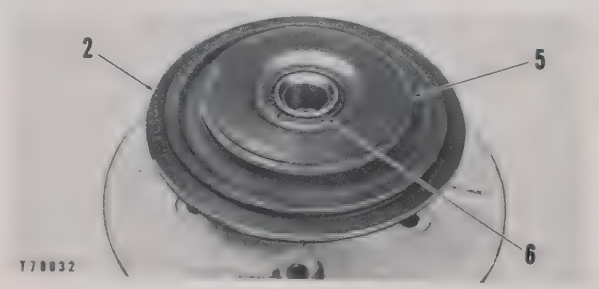
Install back plate **(5)** on bearing housing **(2)** and secure in place with snap ring **(6)**.



BEARING INSTALLATION
1–Wear washer. 2–Bearing housing. 3–Bearings. 4–Snap rings.

NOTE

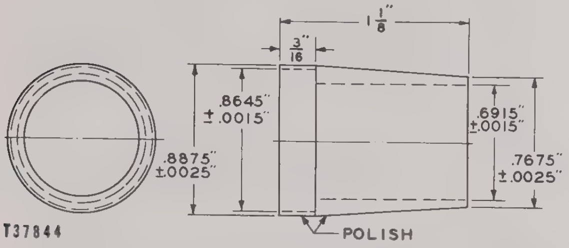
Beveled-type snap ring **(6)** must be installed with the flat side toward the back plate. Make certain the ring is secure in the groove.



BACK PLATE INSTALLATION
2–Bearing housing. 5–Back plate. 6–Snap ring.

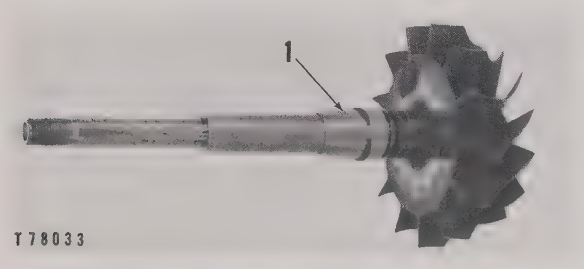
Rotating Parts

1. Lubricate the piston ring-type seal grooves and, with the aid of fabricated ring expander sleeve **(1)**, install the two piston ring-type seals on the shaft.



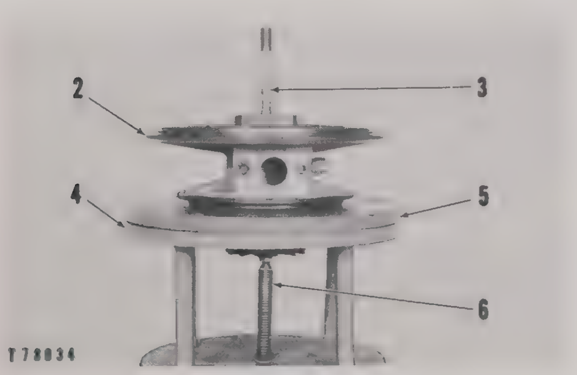
DETAIL FOR FABRICATING RING EXPANDER SLEEVE

2. Remove the sleeve and rotate the rings until the gaps are 180° apart.



INSTALLING PISTON RING SEAL
1–Ring expander sleeve.

3. Center the ring seals on the shaft with the gaps 180° apart and insert the shaft into the turbine end of the bearing housing. If the rings do not enter the housing easily, remove the shaft and re-center the rings.
4. Place bearing housing **(2)** and shaft **(3)** on the fixture **(4)**, with the aid of fixture adapter **(5)**, and support the shaft with support screw **(6)**.

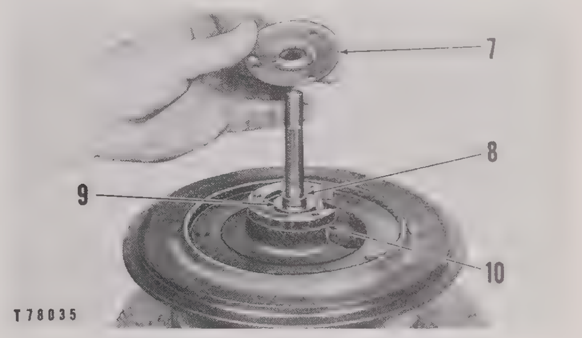


SHAFT INSTALLATION
2–Bearing housing. 3–Shaft. 4–Fixture. 5–Fixture adapter. 6–Support screw.

5. Install oil retainer **(10)**, thrust ring **(9)**, spacer **(8)** and thrust bearing **(7)**.

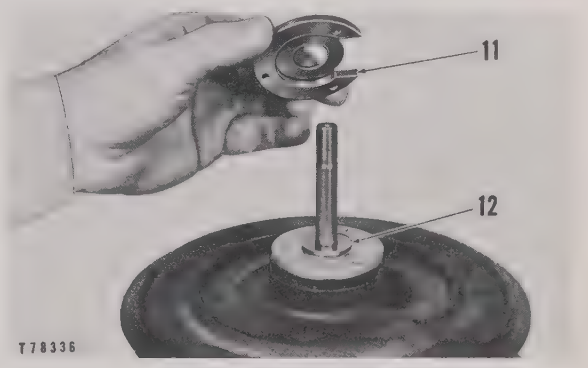
NOTE

The bolt holes in the oil retainer and thrust bearing are staggered to eliminate the possibility of installing these items incorrectly.



INSTALLING THRUST BEARING
7–Thrust bearing. 8–Spacer. 9–Thrust ring. 10–Oil retainer.

6. Install thrust ring **(12)** and oil retainer **(11)**.



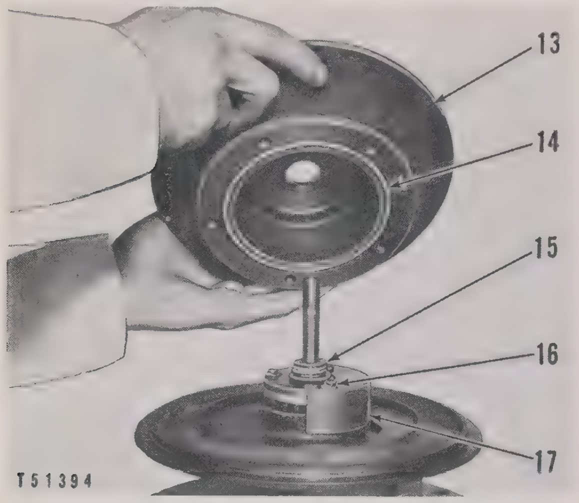
INSTALLING OIL RETAINER
11–Oil retainer. 12–Thrust ring.

7. Install oil deflector **(17)** and bolts **(16)**. Bend the locks to secure the bolts in place.
8. Slip sleeve **(15)** over the shaft so the end containing the piston ring-type seal groove faces away from the bearing housing.
9. If sleeve **(15)** has an interference fit on the shaft, heat the sleeve in oil at 250° F. for a few minutes to facilitate installation. Allow sleeve to cool before tightening the impeller retaining nut.

NOTE

If the piston ring-type seals were removed from the sleeve **(15)**, it will be necessary to install them again upon installation of the sleeve. If the rings were not removed, the sleeve and rings can be installed as a unit.

10. Lubricate the rings and rotate them until their gaps are 180° apart.

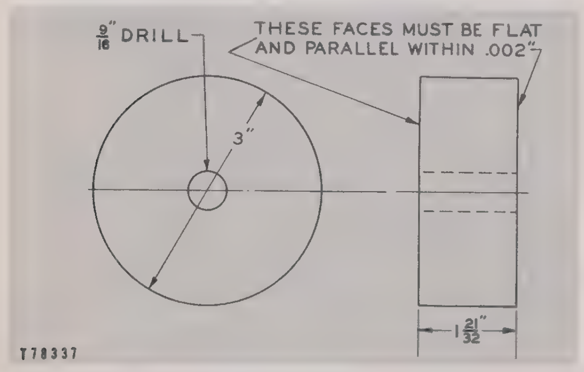


INSTALLING COMPRESSOR BACK PLATE
13–Compressor back plate. 14–O-ring seal. 15–Sleeve. 16–Bolts (three). 17–Oil deflector.

11. Install O-ring seal **(14)** in the groove provided in compressor back plate **(13)** and place the back plate over the shaft, carefully lowering it to the assembled position. Tighten the bolts securing the back plate in this position. See the SPECIFICATIONS.

CAUTION

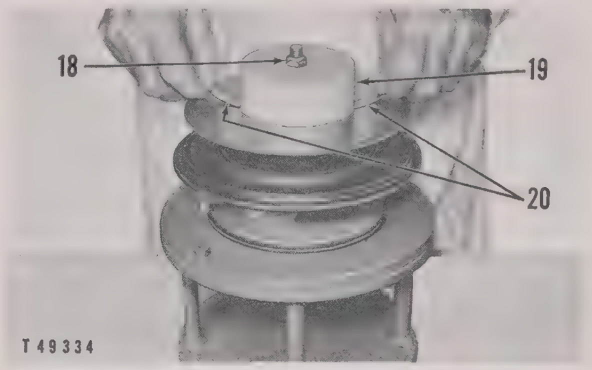
Use care to prevent ring breakage when seating ring seals in the compressor back plate bore. Do not force the rings into the bore.



SPACER BLOCK

12. Place the approximate amount of shims needed on the shaft. Install spacer block **(19)** and nut **(18)**. Tighten the nut to the specified torque.

13. Using a thickness gauge **(20)** on each side of the spacer block as illustrated, check the impeller-to-compressor back plate clearance. Measure with the block pushed toward the impeller end. This clearance is regulated by the shims under the impeller; add or remove shims as required. See the SPECIFICATIONS for correct clearance.



CHECKING IMPELLER TO HOUSING CLEARANCE
18–Nut. 19–Spacer block. 20–Thickness gauges.

14. Remove nut **(18)** and spacer block **(19)**.

15. Carefully install the impeller on the shaft.

NOTE

Make certain the support screw pushes the shaft firmly toward the impeller end during this operation. Also make certain the impeller bottoms on the shaft.

16. Install a new nut and tighten to the torque value specified in the SPECIFICATIONS.

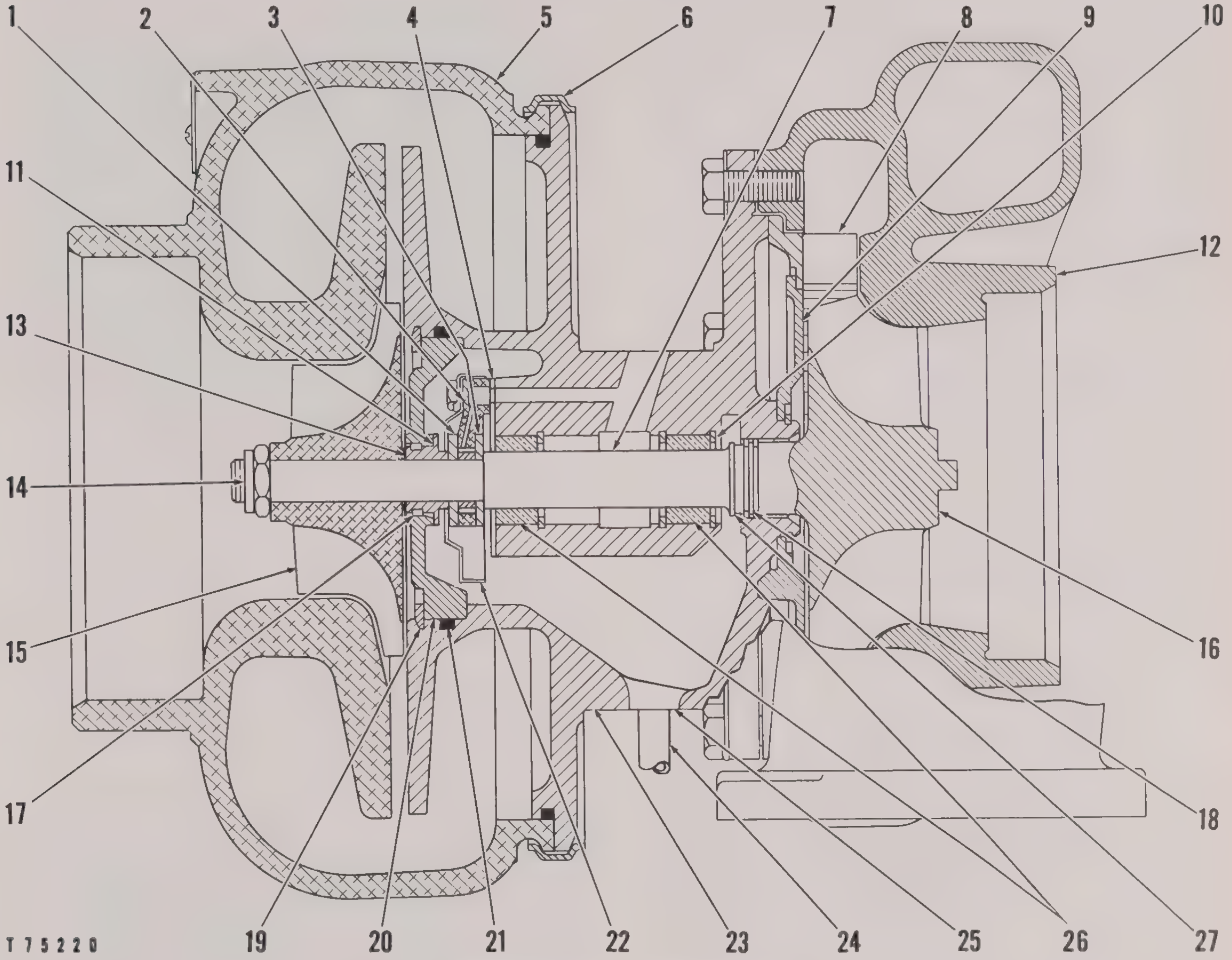
INSTALLING NUT

17. Recheck the impeller-to-back plate clearance by placing the appropriate thickness gauge under the impeller wheel. Also check again for proper end clearance.

18. Make a final inspection to determine if any blades have been accidentally damaged or bent during the assembly operation.

19. Install the nozzle, turbine housing and compressor cover.

INTRODUCTION



TURBOCHARGER CONSTRUCTION

1–Thrust ring.
2–Thrust bearing.
3–Thrust ring.
4–Spacer.
5–Compressor cover.
6–Clamp.
7–Shaft.
8–Nozzle.
9–Turbine back plate.
10–Wear washer.
11–Sleeve.
12–Turbine housing.
13–Shims.
14–Nut.
15–Compressor impeller.
16–Turbine wheel.
17–Ring seals.
18–Ring seals.
19–Retaining ring.
20–Insert.
21–Seal.
22–Oil deflector.
23–Bearing housing.
24–Vent tube.
25–Oil drain hole.
26–Bearings.
27–Oil thrower.

The turbocharger is designed to increase diesel engine power output. The turbocharger utilizes diesel exhaust gases to drive the compressor impeller **(15)** for supercharging the diesel engine.

Turbine wheel **(16)** is located in the turbine housing and is permanently secured to one end of shaft **(7)**. The impeller is secured to the other end of the shaft by nut **(14)** to form an integral rotating assembly. To assure reliability and freedom from vibration, all parts of the rotating assembly have been carefully dynamically balanced. The compressor impeller can be replaced separately.

Vent tube **(24)** vents the oil cavity to the crankcase. Venting this cavity promotes draining of oil from bearing housing, and therefore away from the seals, thus reducing the work-load imposed on the seals.

The rotating assembly is supported by two full floating pressure lubricated bearings **(26)**. Filtered engine oil is supplied to the bearings through passages in the housing to lubricate the shaft bearings **(26)** and thrust bearing **(2)**. This oil aids in removal of excessive heat. Oil returns from turbocharger to the crankcase through an external tube at **(25)**. Thrust loads are absorbed by stationary thrust bearing **(2)** and rotating thrust rings **(1)** and **(3)**. Oil deflector **(22)** contains and routes the oil thrown from the shaft and thrust rings back to drain opening **(25)**.

Ring seals **(17)** and **(18)** on either end of the shaft prevent oil from escaping the bearing housing.

Beside housing the turbine wheel, the turbine housing acts as a chamber for exhaust gases from the diesel engine. Gases are directed through the turbine housing into contact with the turbine blades by the nozzle **(8)**.

Shims **(13)**, located between impeller **(15)** and sleeve **(11)**, adjust the impeller-to-cover clearance.

Always handle the turbocharger carefully to avoid damage to any of its components.

ALTITUDE OPERATION

Maximum turbocharger speed is determined by the rack setting, the high idle speed setting and the altitude at which the engine is operated. The rack setting has been set to permit the engine to be operated at the altitude given on the warning plate on the instrument panel or valve cover. The high idle speed setting is not the same for all altitudes. If the high idle speed or the rack setting is greater than specified for the altitude at which the engine is operated. serious damage to engine or turbocharger parts can result.

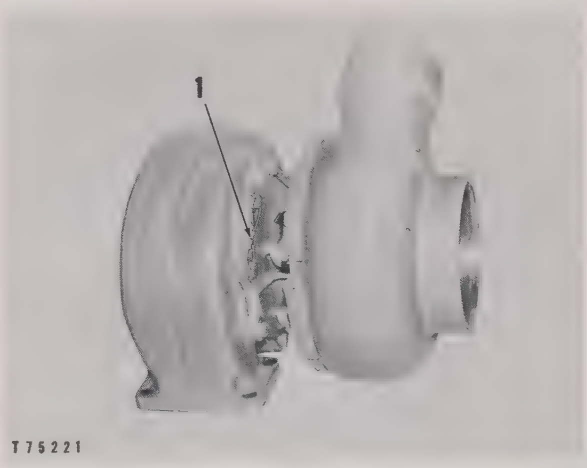
The maximum altitude at which the engine can be operated is specified on the altitude warning plate located on the valve cover or instrument panel. The governor housing and turbocharger are sealed to prevent serious engine damage due to operation of the engine with incorrect settings or turbocharger nozzle. Changes to the turbocharger, rack setting, or high idle speed should be made only by a Caterpillar dealer serviceman.

The engine can be operated at a lower altitude than specified on the warning plate without danger of engine damage, but with slightly less than maximum performance. When operated at a higher altitude, the rack setting and high idle speed setting must be changed only by a Caterpillar dealer serviceman. After making any changes, stamp the new altitude limit on the altitude warning plate.

Also, stamp the new high idle, full load speed, and rack setting on the governor warning plate. Reseal the governor housing for continued protection.

SEALING OF THE TURBOCHARGER

The turbocharger is sealed at the factory. Factory installed seals are identified by the letters CTCO. Dealer's, 6H4160 Sealing Tool Assembly, impresses the letters DLR on the seals.



TURBOCHARGER FACTORY SEAL
1–Seal.

CHECKING BEARING CLEARANCE

A quick check of bearing condition can be made without disassembling the turbocharger. This can be done by inspecting the compressor impeller, turbine wheel, turbine housing and compressor cover. If there is no indication of either the impeller rubbing the compressor cover or the turbine wheel rubbing the turbine housing, the bearing clearances are generally satisfactory.

A more reliable check of bearing condition can be made only when the turbocharger is disassembled and the bearings, shaft journal and housing bore diameter can actually be measured. See the topic, SPECIFICATIONS, for these diameters.

While the turbocharger is disassembled, carefully check the back surface of the compressor impeller for sign of contact with the cover. Contact in this area indicates a worn thrust bearing or thrust rings.

CHECKING TURBOCHARGER SHAFT END CLEARANCE

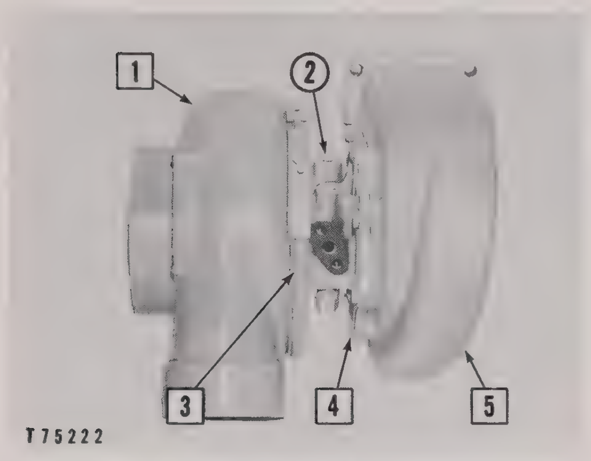
See the topic, SPECIFICATIONS, for normal and permissible shaft end clearance (axial movement). End clearance is checked with a dial indicator, either on the engine or off the engine. If the permissible clearance is exceeded, the turbocharger should be reconditioned.

DISASSEMBLY OF THE TURBOCHARGER

Compressor Cover and Turbine Housing Removal and Installation

1. With all turbocharger openings covered, wash exterior of the turbocharger thoroughly with a nonflammable fluid before disassembly.

2. Prior to disassembly, mark compressor cover **(1)**, turbine housing **(5)** and bearing housing **(2)** to insure correct positioning at assembly.

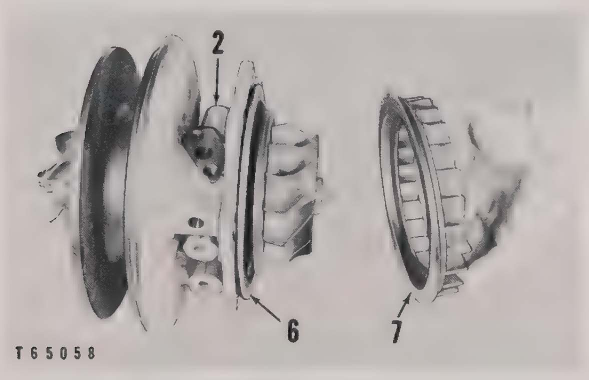

1
2
3
4
5
T75222

PREPARING TO REMOVE COMPRESSOR COVER AND TURBINE HOUSING
1–Compressor cover. 2–Bearing housing. 3–Clamp. 4–Bolts (eight). 5–Turbine housing.

CAUTION

Use caution when removing turbine housing to prevent turbine nozzle **(7)** from falling.

3. Lift nozzle **(7)** from turbine back plate **(6)**.



REMOVING NOZZLE
2–Bearing housing. 6–Turbine back plate. 7–Nozzle.

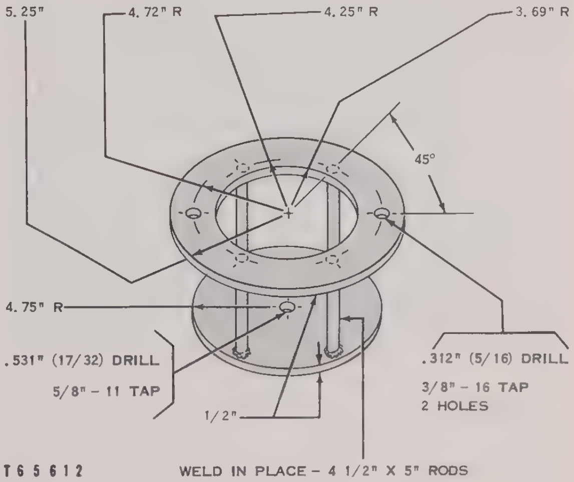
4. Before installing the compressor cover and turbine housing, see the topic, CLEANING AND INSPECTION.
5. Complete the assembly. Turn the impeller by hand to be certain there is no rubbing or binding within the turbocharger.

Rotating Parts

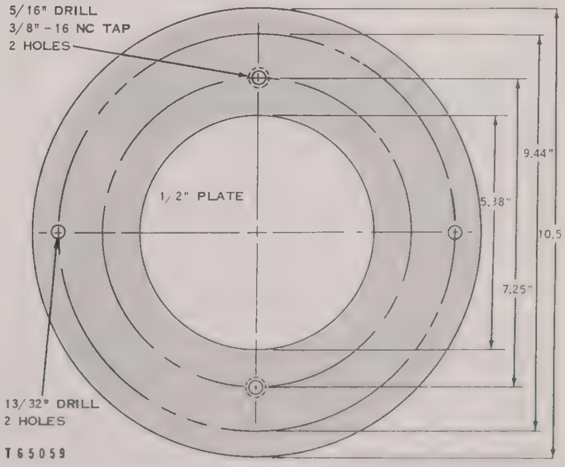
Before disassembly of the rotating assembly, measure shaft end clearance as previously described. If clearance is excessive, or if either the turbine wheel or impeller has rubbed against the housing or cover, replace the bearing and/or thrust bearing, and thrust rings. Bent impeller blades require replacement of the impeller. Turbine blades, which are noticeably bent require replacement of the turbine and shaft assembly.

Bearing failure can damage the shaft journals and/or thrust bearing or rings. Excessive wear or roughness renders the shaft unsuitable for reuse. If the shaft journals measure less than the specified diameter, install a new turbine and shaft assembly. Visual inspection and experience are the only ways to determine when the roughness of shaft prohibits reusing the assembly. New bearings will not correct excessive wear on the thrust bearing or thrust rings.

Installing new bearings does not eliminate necessity of inspecting and cleaning rotating parts.

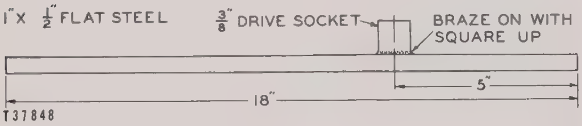

5.25"
4.72" R
4.25" R
3.69" R
45°
4.75" R
.531" (17/32) DRILL
5/8" - 11 TAP
1/2"
.312" (5/16) DRILL
3/8" - 16 TAP
2 HOLES
T65612
WELD IN PLACE - 4 1/2" X 5" RODS

FIXTURE


5/16" DRILL
3/8" - 16 NC TAP
2 HOLES
1/2" PLATE
9.44"
5.38"
10.5
7.25"
13/32" DRILL
2 HOLES
T65059

FIXTURE ADAPTER

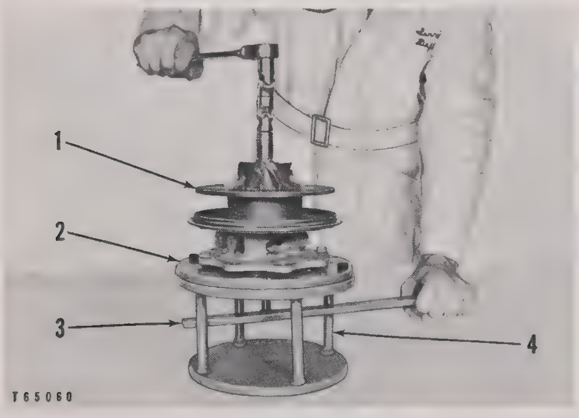
1. Assemble fixture adapter **(2)** to fixture **(4)**. Place bearing housing **(1)**, containing the rotating parts, on fixture adapter with turbine wheel down as illustrated.
2. Remove the nut. The rotating assembly can be held stationary by wrench **(3)** as shown.



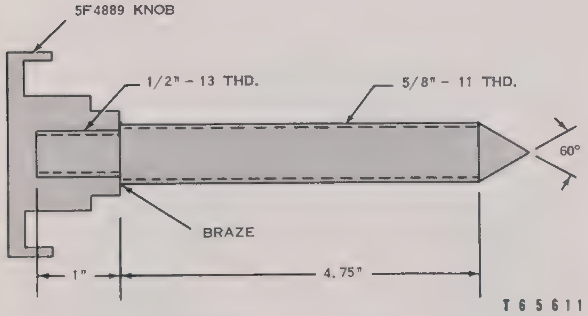
WRENCH

CAUTION

Take care to prevent any distortion of the blades. It is also recommended that a double universal joint be used to prevent possible bending of the shaft.

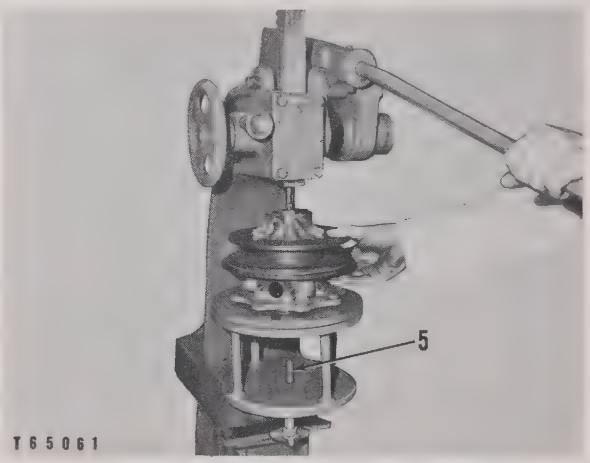


REMOVING NUT
1–Bearing housing. 2–Fixture adapter. 3–Wrench. 4–Fixture.



SUPPORTING SCREW

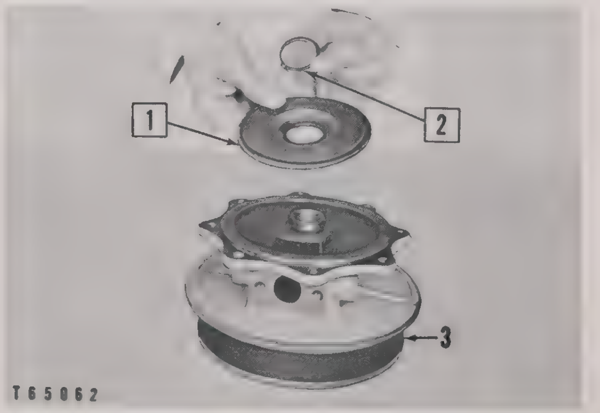
3. Thread supporting screw **(5)** into the base of the fixture to support the turbine wheel and shaft after it is pressed from the impeller. Leave a space between the end of the screw and the turbine wheel equal to, or slightly greater than, the thickness of the impeller. This will allow unobstructed pressing and prevent the turbine wheel from being damaged.
4. Using a press and a pin, press the shaft and turbine wheel from the impeller hub as shown.



PRESSING SHAFT AND TURBINE WHEEL FROM IMPELLER
5–Supporting screw.

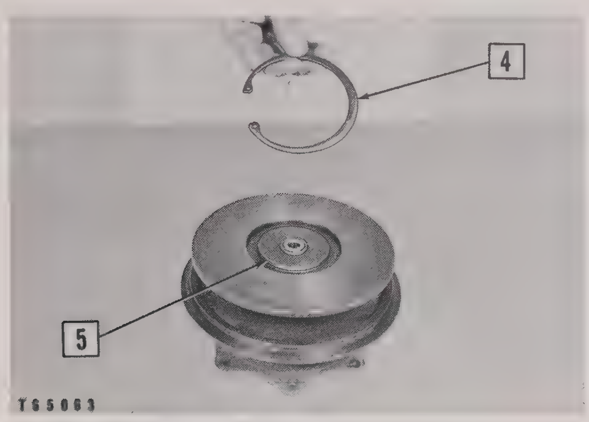
5. Remove the impeller and shims.
6. Remove the turbine wheel and shaft.
7. Measure the shaft journal diameters and inspect the journals for roughness. If the journal diameters are less than specified, the shaft and turbine assembly must be replaced. See the topic, SPECIFICATIONS, for correct dimensions.
8. Inspect the ring seals and measure their thickness. Measure the width of the ring seal grooves. See the topic, SPECIFICATIONS.

Bearing Housing



REMOVING TURBINE BACK PLATE
1–Back plate. 2–Snap ring. 3–Bearing housing.

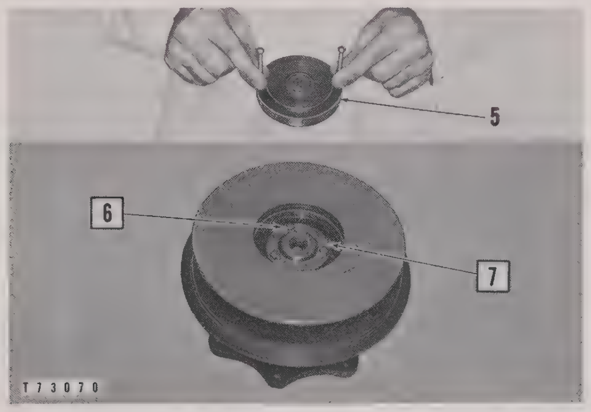
1. Invert bearing housing **(3)**.



PREPARING TO REMOVE INSERT
4–Retaining ring. 5–Insert.

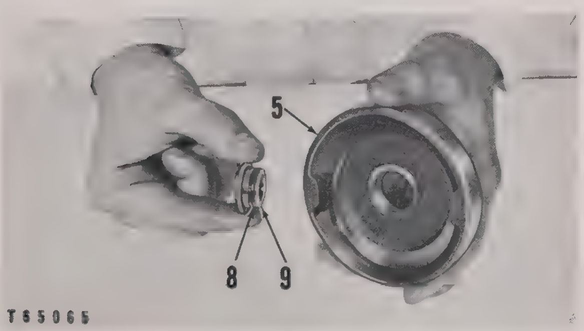
NOTE

Use two 10-24 NC machine screws to remove insert **(5)** from housing **(3)**.



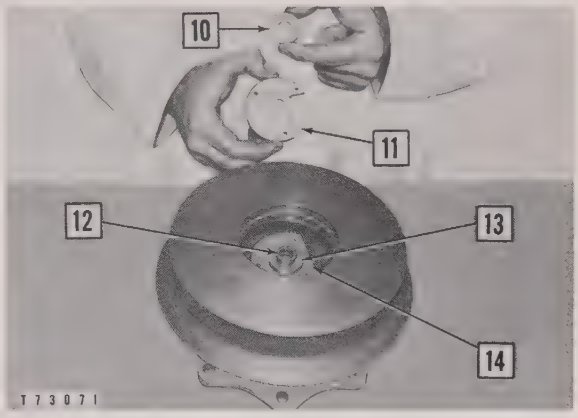
REMOVING INSERT
5–Insert. 6–Bolts (three). 7–Oil deflector.

2. Remove sleeve **(9)** from insert **(5)**.



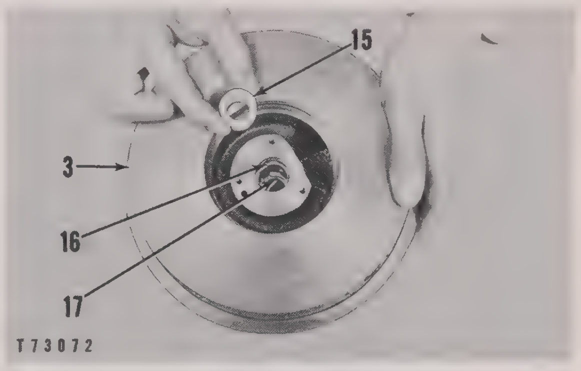
REMOVING SLEEVE
5–Insert. 8–Ring seals. 9–Sleeve.

3. Inspect seals **(8)** and the groove in sleeve **(9)**. See the topic, SPECIFICATIONS.



THRUST BEARING REMOVAL
10–Thrust ring. 11–Thrust bearing. 12–Spacer. 13–Thrust ring. 14–Spacer.

4. Remove bearing **(15)** from housing **(3)**.



BEARING REMOVAL
3–Bearing housing. 15–Bearing. 16–Snap rings (three). 17–Bearing and wear washer.

5. Inspect and measure thrust rings **(10)** and **(13)**, thrust bearing **(11)**, the bore in bearing housing **(3)**, the wear washer and bearings **(15)** and **(17)**. See the group, SPECIFICATIONS.

CAUTION

Replace bearings **(15)** and **(17)** if they do not measure up to the SPECIFICATIONS.

CLEANING AND INSPECTION

Inspect all rotating parts for binding and damage caused by rubbing on adjacent parts.

Wash all parts with cleaning solvent and dry thoroughly. Use a piece of wood to clean the carbon from the turbine housing and the nozzle.

The turbine wheel must be cleaned with cleaning solvent to dissolve the carbon. When hard carbon deposits are formed, soaking in a solvent-type cleaner for an hour or more is required. The loosened particles must all be scraped off with a stiff brush or a specially shaped piece of wood and, if necessary, the whole process repeated. If the wheel is covered with soot only, washing with a stiff brush and cleaning solvent and then rinsing with clean water will be sufficient.

CAUTION

The rotating components must be thoroughly cleaned in order to maintain critical balance of the unit. Do not use a wire brush or wheel.

ASSEMBLING TURBOCHARGER

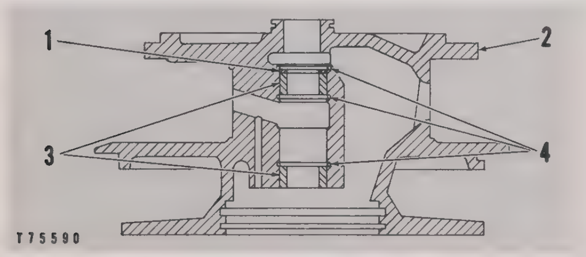
Before assembling, be certain all parts are thoroughly clean. Extreme care must be taken to keep out dirt and foreign material.

Bearing Housing

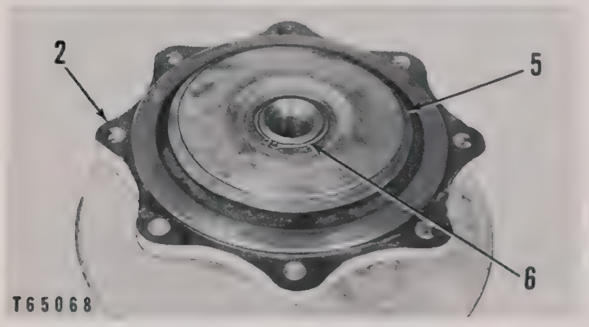
Install snap rings **(4)**, wear washer **(1)** and bearings **(3)** in the bearing housing **(2)** as shown.

CAUTION

Exercise extreme care during installation of the snap rings **(4)** to prevent scratching the bearing housing bore. Each snap ring must be installed with the flat side facing the bearing for which it is acting as a retainer. Lubricate the bearings prior to installation.



BEARING INSTALLATION
1–Wear washer. 2–Bearing housing. 3–Bearings. 4–Snap rings.



BACK PLATE INSTALLATION
2–Bearing housing. 5–Back plate. 6–Snap ring.

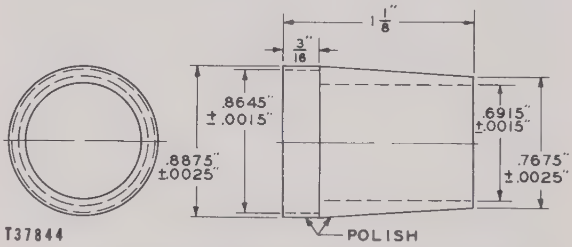
Install back plate **(5)** on the bearing housing **(2)** and secure with snap ring **(6)**.

NOTE

The beveled-type snap ring **(6)** must be installed with the flat side toward the back plate. Make certain the ring is secure in the groove.

Rotating Parts

1. Lubricate the ring grooves and use fabricated ring expander sleeve **(1)** to install the two ring seals on the shaft.

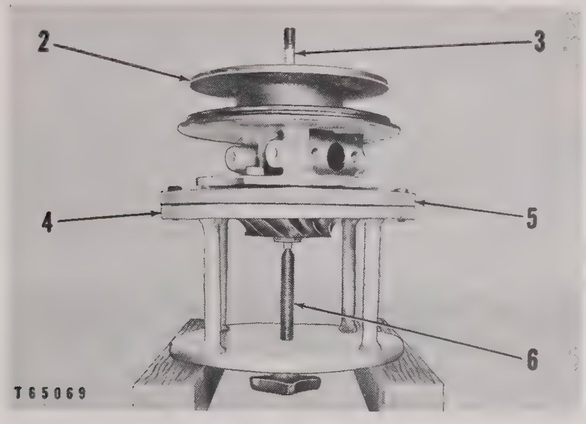


DETAIL FOR FABRICATING RING EXPANDER SLEEVE

2. Remove the sleeve and rotate the rings until the gaps are 180° apart.

INSTALLING RING SEAL
1–Ring expander sleeve.

3. Center the ring seals on the shaft with the gaps 180° apart and insert the shaft into the turbine end of the bearing housing. If the rings do not enter the housing easily, remove the shaft and re-center the rings.
4. Using fixture adapter **(5)**, place the bearing housing **(2)** and shaft **(3)** on fixture **(4)**. Support the shaft with support screw **(6)**.

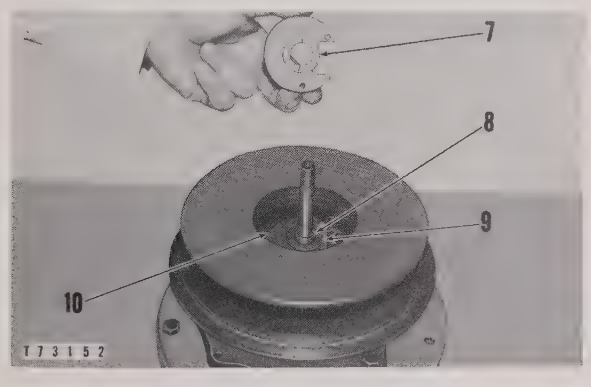

2
3
4
5
6
T65069

SHAFT INSTALLATION
2–Bearing housing. 3–Shaft. 4–Fixture. 5–Fixture adapter. 6–Support screw.

5. Install spacer **(10)**, thrust ring **(9)**, spacer **(8)** and thrust bearing **(7)**.

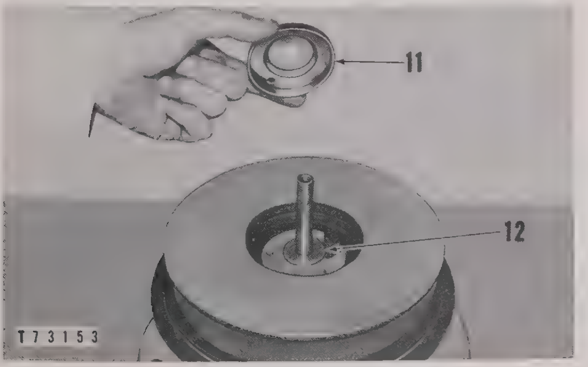
NOTE

The bolt holes in the spacer and thrust bearing are staggered to eliminate the possibility of installing these items incorrectly.


7
8
9
10
T73152

INSTALLING THRUST BEARING
7–Thrust bearing. 8–Spacer. 9–Thrust ring. 10–Spacer.

6. Install thrust ring **(12)** and oil deflector **(11)**.


11
12
T73153

INSTALLING OIL RETAINER
11–Oil deflector. 12–Thrust ring.

7. Tighten bolts **(17)** to torque given in the group, SPECIFICATIONS, and bend the locks which secure bolts **(17)**.
8. Place sleeve **(14)** over the shaft.

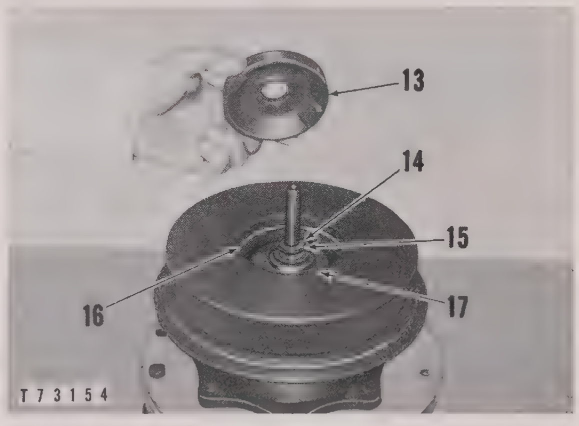
NOTE

Position sleeve **(14)** with ring seal grooves away from the bearing housing.

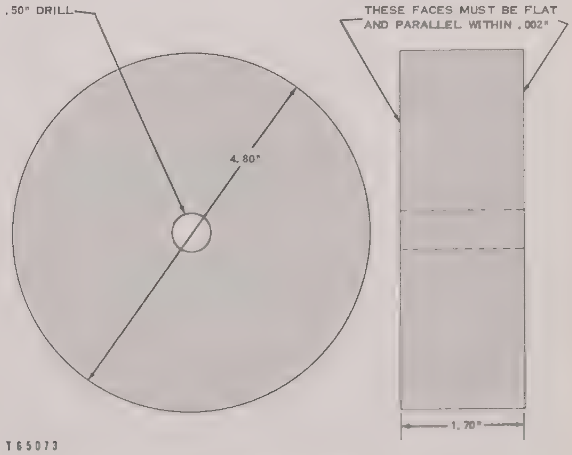
9. Install ring seals **(15)** on sleeve **(14)**. Position the gaps 180° apart.
10. Install seal **(16)**.
11. Install insert **(13)**. Position the retaining ring with the flat side toward the insert.

CAUTION

Install the insert with care to avoid damaging the ring seals.

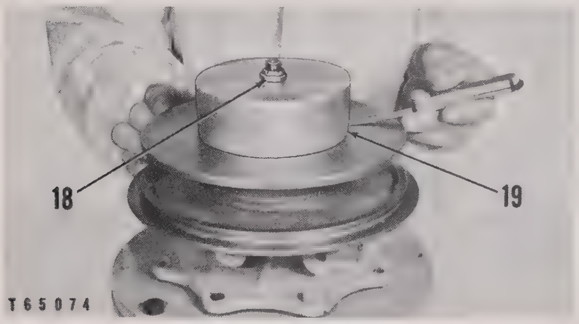

13
14
15
16
17
T73154

INSTALLING INSERT
13–Insert. 14–Sleeve. 15–Ring seals. 16–Seal. 17–Bolts (three).


.50" DRILL
THESE FACES MUST BE FLAT AND PARALLEL WITHIN .002"
4.80"
1.70"
T65073

SPACER BLOCK

12. Place the approximate amount of shims needed on the shaft and install spacer block **(19)** and nut **(18)**. Tighten the nut to the specified torque.



CHECKING IMPELLER TO HOUSING CLEARANCE
18–Nut. 19–Spacer block.

13. Thread the support screw against the turbine end of the shaft just enough to remove all end clearance. Using a thickness gauge on each side of the spacer block, check impeller to bearing housing clearance. This clearance is regulated by shims under the impeller; add or remove shims as required. See the SPECIFICATIONS for correct clearance.

14. Remove nut **(18)** and spacer block **(19)** and install the correct number of shims.

15. Carefully install impeller on the shaft.

NOTE

Make certain the support screw pushes the shaft firmly toward the impeller end during this operation. Also make certain the impeller bottoms on the shaft.

16. Install a new nut and tighten to the specified torque. See the SPECIFICATIONS.

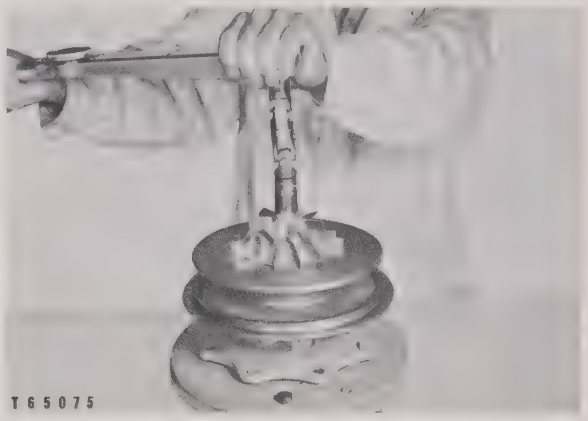
CAUTION

Use a double universal joint to prevent bending the shaft.

17. Recheck the impeller to bearing housing clearance and the end clearance.

18. Make a final inspection to determine if any blades have been accidentally damaged or bent during the assembly operation.

19. Install the nozzle and turbine housing. The two bolts marked X have drilled heads for installation of the turbocharger seal. The four bolts marked Y are for installation of the turbocharger mounting bracket. Tighten the bolts to the torque value given in the SPECIFICATIONS and secure the bolt locks.



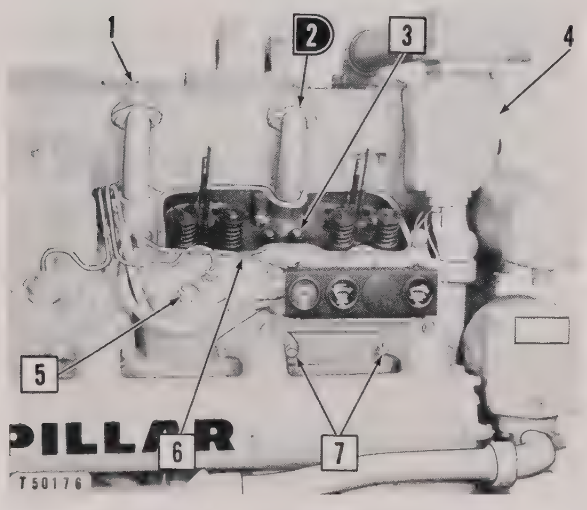
INSTALLING NUT

20. Install the compressor cover with a new seal and tighten the band clamp to the torque value given in the SPECIFICATIONS.

Cylinder Heads

Each cylinder head covers two cylinders. Water directors direct the flow of coolant toward the valve ports and precombustion chambers. Seals and ferrules seal the water passages between the cylinder head and the cylinder block.

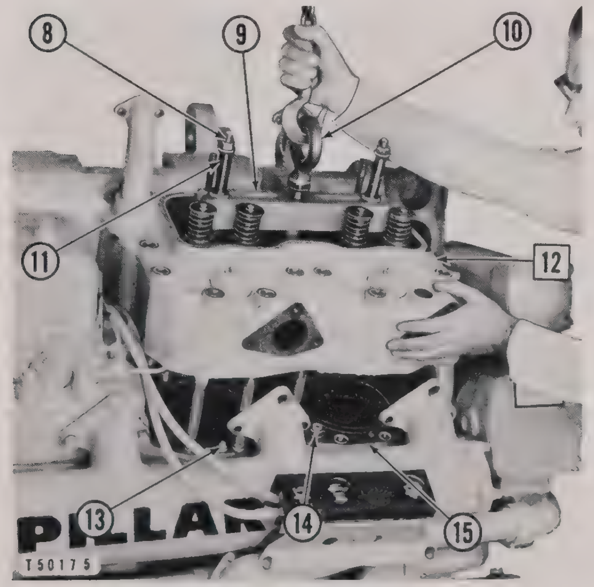
REMOVAL AND INSTALLATION



PREPARING TO REMOVE CYLINDER HEAD

☐ Remove ◗ Disconnect

1–Exhaust manifold. 2–Pipes (two per cylinder head). 3–Nuts. 4–Regulator housing. 5–Nuts. 6–Fuel lines (two per cylinder head). 7–Bolts (six per cylinder head).



REMOVING CYLINDER HEAD

☐ Remove

8–Stud. 9–Crossbar. 10–Eyebolt. 11–½" x 3" pipe. 12–Cylinder head. 13–Ferrule. 14–Seal. 15–Head gasket.

1. Drain the coolant from the engine.
2. Remove the valve mechanism as described in the covering topic.
3. Remove the eight bolts which secure the exhaust manifold **(1)** to the cylinder head.
4. When the right front cylinder head is being removed, as shown, the water temperature regulator housing **(4)** must be removed. See the covering topic.
5. Use the crossbar **(9)** from the 8B7548 Push Puller with two ½" pipe nipples **(11)** 3 inches long, two 1B4205 Nuts and flat washers attached to the rocker arm studs **(8)** as shown. Attach a 1" eyebolt **(10)** to the bar and using a suitable hoist, lift the cylinder head **(12)** from the engine.
6. Inspect the seals **(14)**, ferrules **(13)** and head gasket **(15)** for damage and replace if necessary.

CAUTION

When installing the head on the cylinder block, see that the ferrules and seals are properly installed, and start properly into the recessed holes in the cylinder head. Rock the head gently until it seats flat on the head gasket.

7. Inspect the manifold gaskets and replace if necessary.
8. Install the hold down nuts **(3)** and **(5)** and washers and tighten the nuts as described in the topic, SPECIFICATIONS.
9. Complete the installation in reverse order of removal.

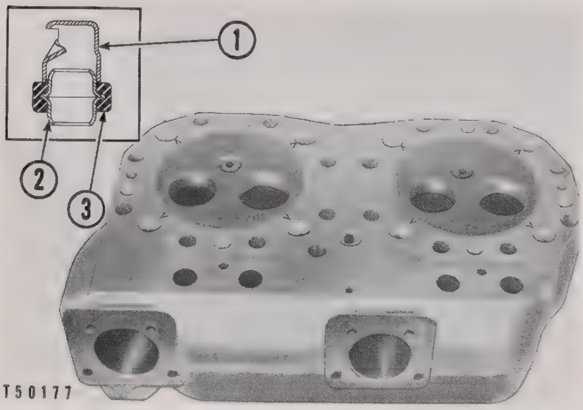
NOTE

See the topic, SPECIFICATIONS, for the correct setting of the valve and compression release clearances.

WATER DIRECTORS

There are eight water directors **(1)** pressed into each cylinder head to direct the flow of coolant. On the exhaust side, coolant is directed toward the precombustion chambers and the exhaust valve ports; and on the inlet side, toward the other side of the valve ports, as indicated by the V-marks. Water directors are pressed into place on the heads after aligning the notch on the director with the V-mark on the head.

The seals **(3)** and copper ferrules **(2)** between the head and top of the block are replaceable. Coat the inner surface of the seal with soap and place the groove in the seal over the ridge on the ferrule before installing.



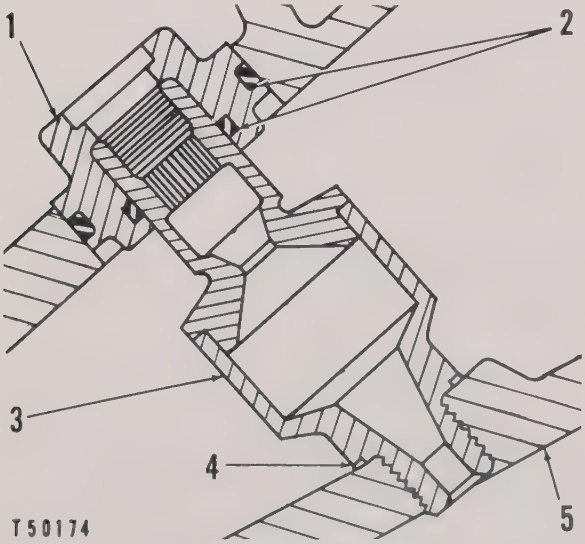
WATER DIRECTORS
1–Water director. 2–Ferrule. 3–Seal.

PRECOMBUSTION CHAMBERS

The precombustion chamber **(3)** is threaded into the cylinder head **(5)** and sealed at the top of the head with a retainer **(1)** and two O-ring seals **(2)**.

The O-ring seals prevent leakage of coolant.

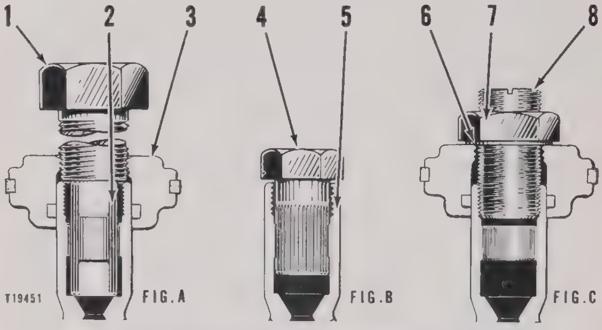
The gasket **(4)** prevents combustion gases from entering the cooling system, as well as preventing the leakage of coolant into the cylinder.



PRECOMBUSTION CHAMBER
1–Retainer. 2–Rubber seals. 3–Precombustion chamber. 4–Gasket. 5–Cylinder head.

Removal and Installation

1. Remove the fuel injection valve assembly.
2. Place a 5F9072 Spacer **(2)** in the precombustion chamber and turn the 1A2208 Bolt **(1)** in the retainer **(3)** against the spacer until the retainer comes out of the cylinder head.

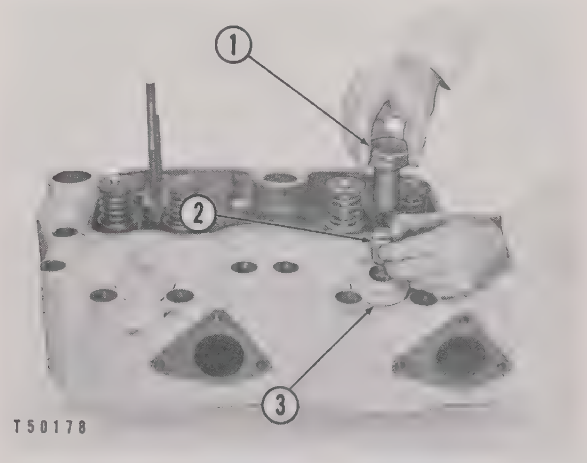


PRECOMBUSTION CHAMBER TOOLS
1–1A2208 Bolt. 2–5F9072 Spacer. 3–Retainer. 4–5F8353 Wrench Adapter. 5–Precombustion chamber. 6–4B4285 Washer. 7–L-1017 Nut. 8–6F5515 Screw.

3. Place the 5F8353 Wrench Adapter **(4)** in the serrations of the precombustion chamber and screw the precombustion chamber out of the head.

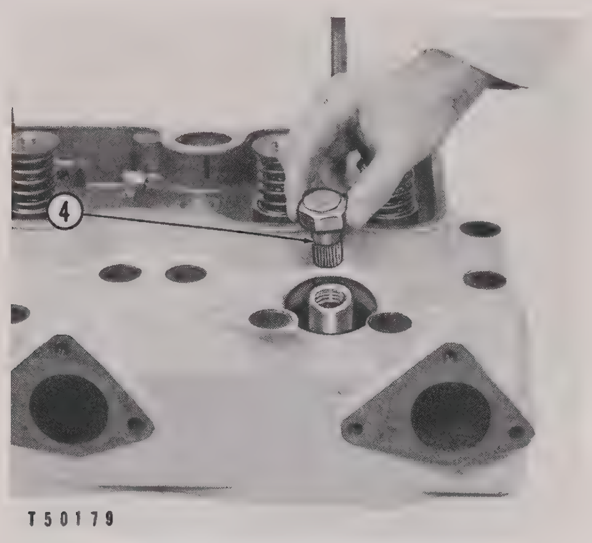
NOTE

If a cylinder head has collected an excessive amount of scale or rust within the water jacket, remove the cylinder head and clean it thoroughly. This is also an indication that the entire cooling system should be cleaned as described in the Operation and Maintenance Instructions.



REMOVING PRECOMBUSTION CHAMBER RETAINER
1–1A2208 Bolt. 2–5F9072 Spacer. 3–Retainer.

4. Place a new gasket, coated on the bottom side with a thin layer of grease, in the head. The grease will help retain the washer while installing the precombustion chamber.
5. Insert the precombustion chamber in the head and tighten with the 5F8353 Wrench Adapter **(4)** to the specified torque as given in the topic, SPECIFICATIONS.



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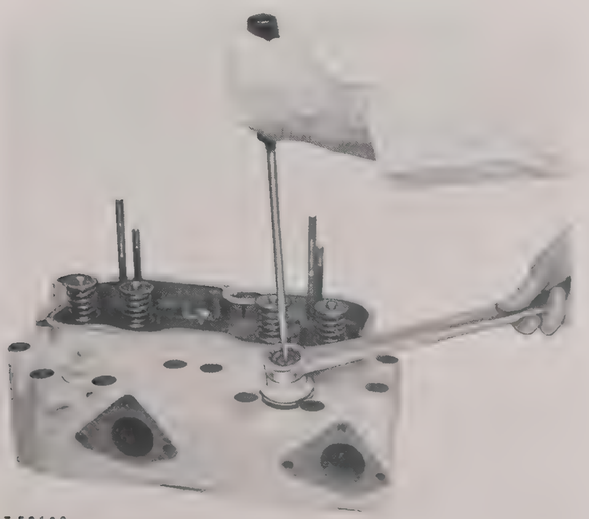
PRECOMBUSTION CHAMBER ADAPTER
4–5F8353 Wrench Adapter.

6. Coat the chamfered portion of the cylinder head and the new rubber seals with soap.
7. Place the retainer over the precombustion chamber and start it into the cylinder head and onto the precombustion chamber.

CAUTION

When starting the retainer do not use force until the seals are properly started. If the seals are not started correctly, they will be damaged and will not seal effectively.

8. Using the 4B4285 Washer **(6)**, the 6F5515 Screw **(8)**, and the L-1017 Nut **(7)**, as illustrated, tighten the retainer until it is bottomed.



T50180

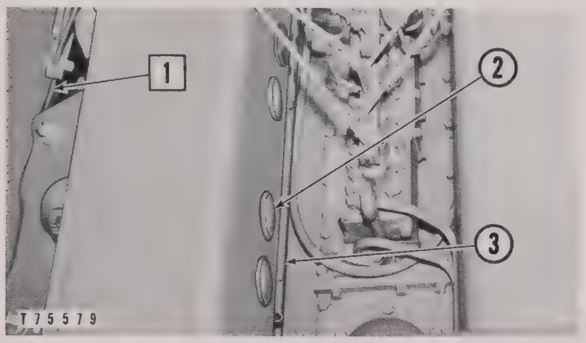
TIGHTENING RETAINER

INTRODUCTION

Each cylinder head covers two cylinders. Water directors direct the flow of coolant toward the valve ports and precombustion chambers. Seals and ferrules seal the water passages between the cylinder head and the cylinder block.

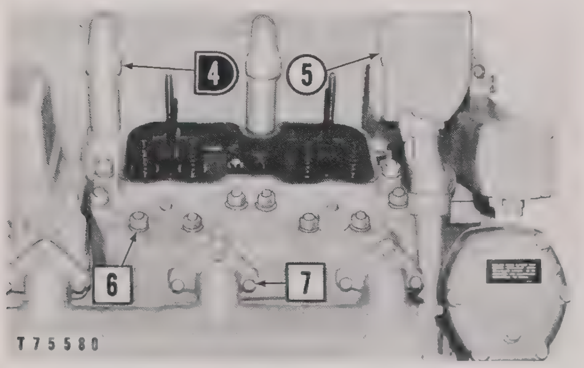
REMOVAL AND INSTALLATION

1. Drain the coolant from the engine.



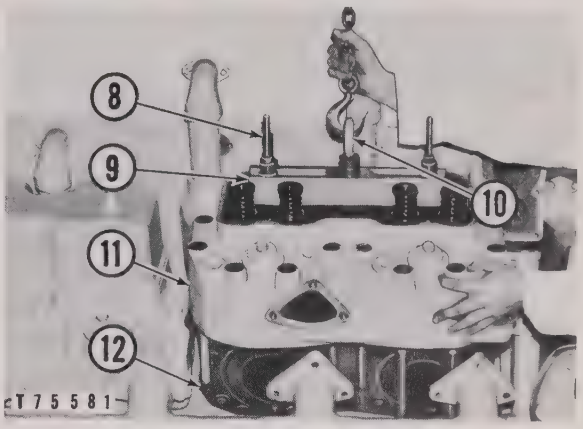
PREPARING TO DISCONNECT EXHAUST MANIFOLD FROM CYLINDER HEAD
1–Fuel injection lines (two per cylinder head). 2–Plugs (four per cylinder head). 3–Shield.

2. Remove plugs **(2)**. Remove the exhaust manifold flange bolts through the openings from which the plugs were removed.
3. Remove shield **(3)** and remove the remaining four exhaust manifold flange bolts. There is a shield support under each pair of bolts.



PREPARING TO REMOVE CYLINDER HEAD
4–Pipes (two per cylinder head). 5–Regulator housing. 6–Nuts and washers (sixteen per cylinder head). 7–Bolts (six per cylinder head).

4. Remove valve mechanism. See covering topic.
5. When the right front cylinder head is being removed, water temperature regulator housing **(5)** must be removed. See the covering topic.
6. Use crossbar **(9)** from the 8B7548 Push Puller with two 1B4205 Nuts and a few flat washers attached to rocker arm studs **(8)** as shown. Attach a 1″ forged eyebolt **(10)** solidly to the crossbar and use a hoist to lift cylinder head **(11)** from the engine. Approx. weight 180 lbs.



REMOVING CYLINDER HEAD
8–Rocker arm studs. 9–Cross bar. 10–Forged eyebolt. 11–Cylinder head. 12–Head gasket.

7. Inspect the seals, ferrules and head gasket **(12)**.

CAUTION

When installing the head on the cylinder block, see that the ferrules and seals are installed properly and start into the recessed holes in the cylinder head. Rock the head gently until it seats flat on the head gasket.

8. Replace manifold gaskets if necessary.
9. Install hold down nuts and washers **(6)**. Tighten the nuts as described in the SPECIFICATIONS.
10. Complete the installation in reverse order of removal.

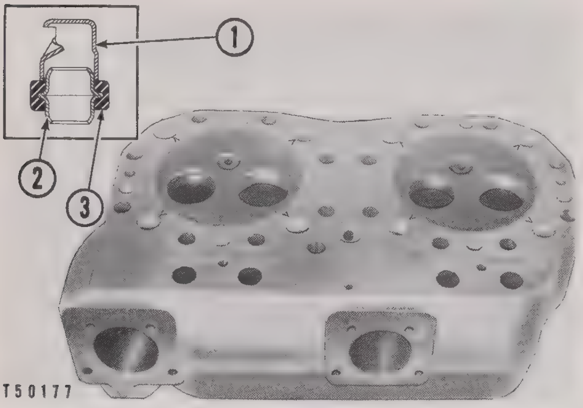
NOTE

See the SPECIFICATIONS for correct settings of valve and compression release clearances.

WATER DIRECTORS

There are eight water directors **(1)** pressed into each cylinder head to direct the flow of coolant. On the exhaust side, coolant is directed toward the precombustion chambers and the exhaust valve ports; and on the inlet side, toward the other side of the valve ports, as indicated by the V-marks. Water directors are pressed into place on the heads after aligning the notch on the director with the V-mark on the head.

The seals **(3)** and copper ferrules **(2)** between the head and top of the block are replaceable. Coat the inner surface of the seal with soap and place the groove in the seal over the ridge on the ferrule before installing.



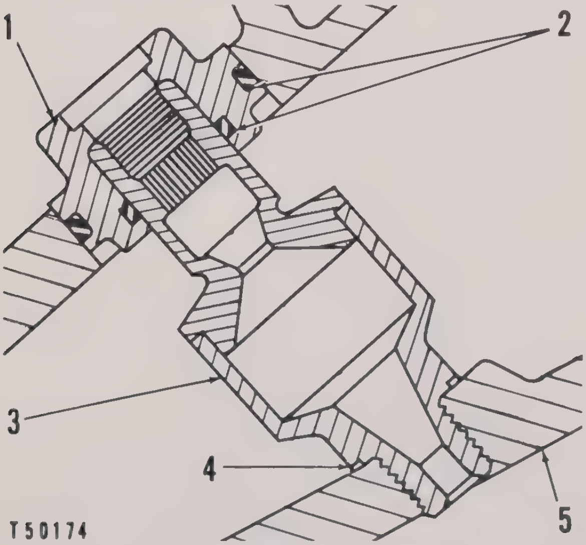
WATER DIRECTORS
1–Water director. 2–Ferrule. 3–Seal.

PRECOMBUSTION CHAMBERS

The precombustion chamber **(3)** is threaded into the cylinder head **(5)** and sealed at the top of the head with a retainer **(1)** and two O-ring seals **(2)**.

The O-ring seals prevent leakage of coolant.

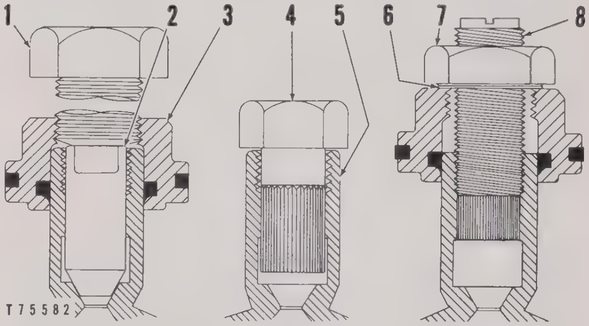
The gasket **(4)** prevents combustion gases from entering the cooling system, as well as preventing the leakage of coolant into the cylinder.



PRECOMBUSTION CHAMBER
1–Retainer. 2–Rubber seals. 3–Precombustion chamber. 4–Gasket. 5–Cylinder head.

Removal and Installation

1. Remove the fuel injection valve assembly.
2. Place a 5F9072 Spacer **(2)** in the precombustion chamber and turn the 1A2208 Bolt **(1)** in the retainer **(3)** against the spacer until the retainer comes out of the cylinder head.

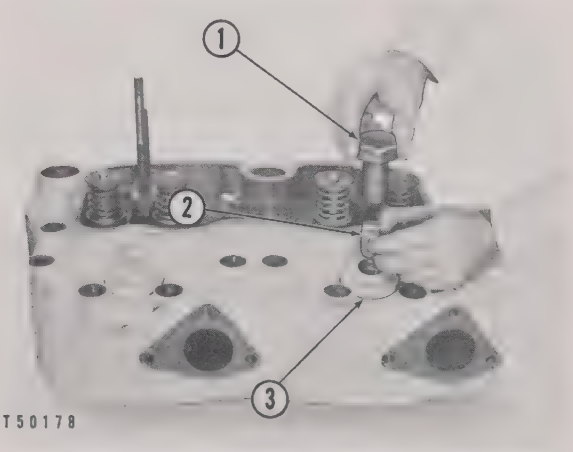


PRECOMBUSTION CHAMBER TOOLS
1–1A2208 Bolt. 2–5F9072 Spacer. 3–Retainer. 4–5F8353 Wrench Adapter. 5–Precombustion chamber. 6–4B4285 Washer. 7–L-1017 Nut. 8–6F5515 Screw.

3. Place the 5F8353 Wrench Adapter **(4)** in the serrations of the precombustion chamber and screw the precombustion chamber out of the head.

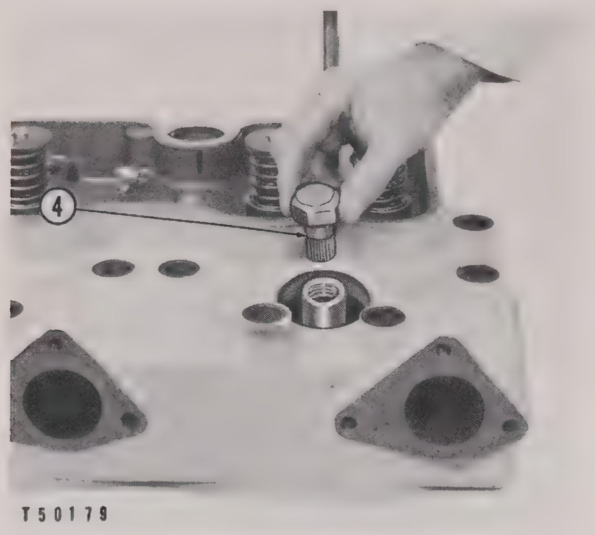
NOTE

If a cylinder head has collected an excessive amount of scale or rust within the water jacket, remove the cylinder head and clean it thoroughly. This is also an indication that the entire cooling system should be cleaned as described in the Operation and Maintenance Instructions.



REMOVING PRECOMBUSTION CHAMBER RETAINER
1–1A2208 Bolt. 2–5F9072 Spacer. 3–Retainer.

4. Place a new gasket, coated on the bottom side with a thin layer of grease, in the head. The grease will help retain the washer while installing the precombustion chamber.
5. Insert the precombustion chamber in the head and tighten with the 5F8353 Wrench Adapter **(4)** to the specified torque as given in the topic, SPECIFICATIONS.



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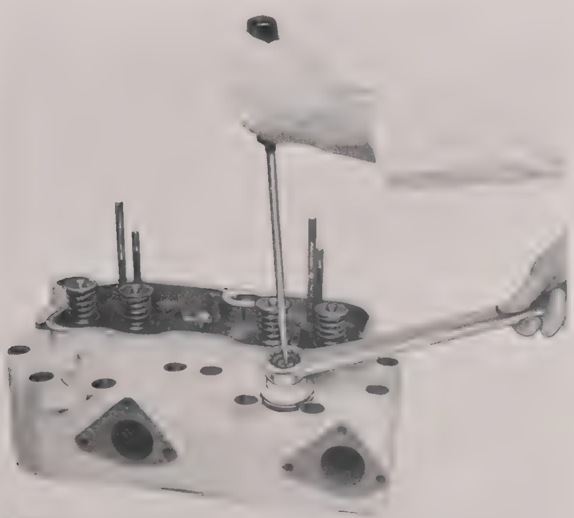
PRECOMBUSTION CHAMBER ADAPTER
4–5F8353 Wrench Adapter.

6. Coat the chamfered portion of the cylinder head and the new rubber seals with soap.
7. Place the retainer over the precombustion chamber and start it into the cylinder head and onto the precombustion chamber.

CAUTION

When starting the retainer do not use force until the seals are properly started. If the seals are not started correctly, they will be damaged and will not seal effectively.

8. Using 4B4285 Washer **(6)**, 6F5515 Screw **(8)**, and L-1017 Nut **(7)**, tighten the nut until the retainer bottoms.



T50180

INSTALLING RETAINER

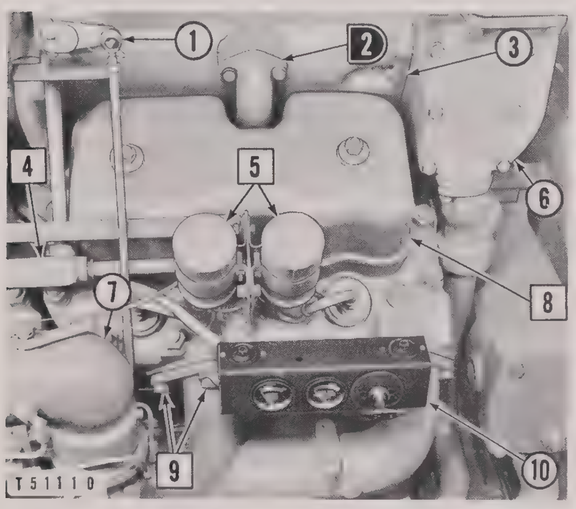
Cylinder Heads

(Natural Gas Engines)

Each cylinder head covers two cylinders. Water directors direct the flow of coolant toward the valve ports and spark plug adapters. Seals and ferrules seal the water passages between the cylinder head and cylinder block.

REMOVAL AND INSTALLATION

1. Drain the coolant from the engine.

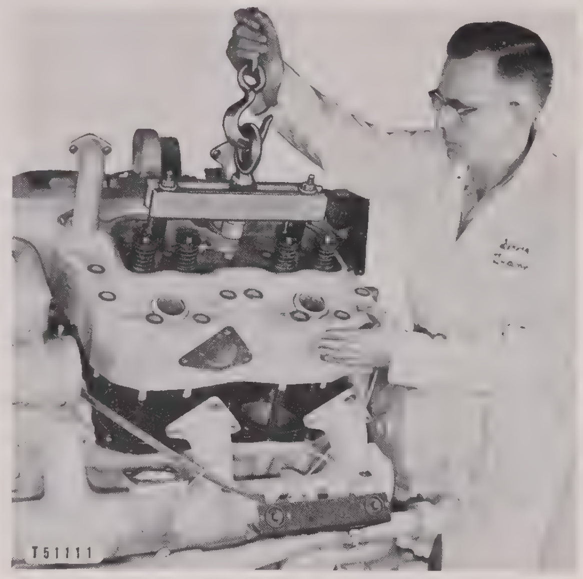


PREPARING TO REMOVE A CYLINDER HEAD

☐ **Remove** ◗ **Disconnect**

1–Carburetor linkage. 2–Pipes (two per cylinder head). 3–Exhaust manifold. 4–Conduit. 5–Coils and coil mounting bracket. 6–Regulator housing. 7–Carburetor. 8–Valve cover. 9–Bolts (six per cylinder head). 10–Instrument panel.

2. Remove the carburetor control linkage **(1)**, the carburetor **(7)**, according to the covering topic, and the governor control bracket.
3. Remove the eight bolts which secure the exhaust manifold **(3)** to the cylinder head.
4. When the right front cylinder head is being removed, as shown, the water temperature regulator housing **(6)** must be removed. See the covering topic.
5. The instrument panel **(10)** and the wires and tubes connected to it should be laid to one side or removed when the right front cylinder head is being removed.
6. Remove the valve mechanism as described in the covering topic.
7. Remove the sixteen nuts from the studs which secure the cylinder head to the cylinder block.

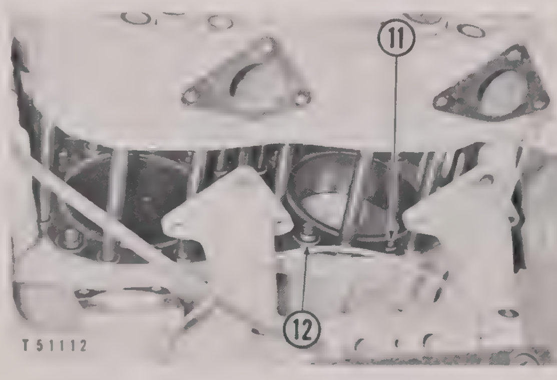


REMOVING CYLINDER HEAD

8. Using the crossbar from the 8B7548 Push Puller with two ½" pipe nipples 3" long, two 1B4205 Nuts and flat washers attached to the rocker arm studs as shown, attach a 1" eyebolt to the bar and using a suitable hoist, lift the cylinder head from the engine as shown.
9. Inspect the seals and ferrules for damage and replace, if necessary. Always install a new cylinder head gasket.
10. Inspect the manifold gaskets and replace if necessary.

CAUTION

When installing the head on the cylinder block, see that the ferrules **(11)** and seals **(12)** are properly installed, and started properly into the recessed holes in the cylinder head. Rock the head gently until it seats flatly on the head gasket.



INSTALLING CYLINDER HEAD

11–Ferrule. 12–Seal.

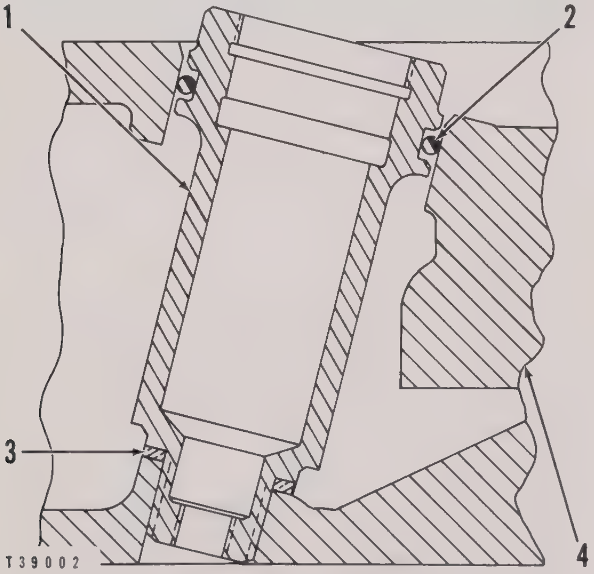
11. Install the cylinder head hold down nuts and washers and tighten the nuts as described in the topic, SPECIFICATIONS.
12. Complete the installation in reverse order of removal.

NOTE

See the topic, SPECIFICATIONS, for the correct setting of the valve and compression release clearances.

SPARK PLUG ADAPTERS

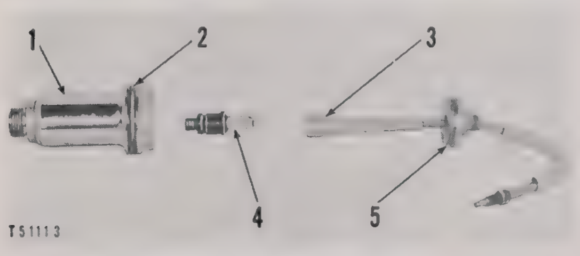
The spark plug adapter **(1)** is threaded into the cylinder head **(4)** and sealed at the top of the head with an O-ring seal **(2)** and at the bottom with a gasket **(3)**.



SPARK PLUG ADAPTER
1–Spark plug adapter. 2–O-ring seal. 3–Gasket. 4–Cylinder head.

Removal and Installation

1. Remove the cover **(5)** and insulator **(3)** from the spark plug adapter **(1)** and the spark plug **(4)**.



SPARK PLUG AND ADAPTER
1–Spark plug adapter. 2–O-ring seal. 3–Insulator. 4–Spark plug. 5–Cover.

2. Using the 3B9082 Spark Plug Wrench in conjunction with the 3563-A Spark Plug Wrench, remove the spark plug from the adapter.
3. Remove the adapter from the cylinder head using the 1F479 Wrench and the 1 5/16″ 8H8536 Socket.

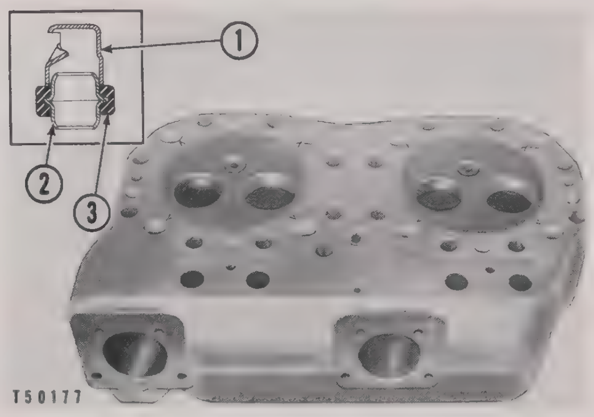
NOTE

If the cylinder head has collected an excessive amount of scale or rust within the water jacket, remove the cylinder head and clean it thoroughly. This is also an indication that the entire cooling system should be cleaned.

4. Install a new gasket in the cylinder head. A thin layer of grease will help retain the gasket while installing the spark plug adapter.
5. Coat the chamfered portion of the cylinder head and the seal **(2)** with oil to aid in installation.
6. Install the spark plug adapter, a new gasket and the spark plug. Tighten to the torque value as given in the topic, SPECIFICATIONS.

WATER DIRECTORS

There are eight water directors **(1)** pressed into each cylinder head to direct the flow of coolant. On the exhaust side, coolant is directed toward the spark plug adapters and the exhaust valve ports, and on the inlet side, toward the other side of the valve ports, as indicated by the V-marks. Water directors are pressed into place on the heads after aligning the notch on the director with the V-mark on the head.



WATER DIRECTORS
1–Water director. 2–Ferrule. 3–Seal.

The seals **(3)** and copper ferrules **(2)**, between the head and top of the block, are replaceable. Place the groove in the seal over the ridge on the ferrule, before installing.

Valves and Valve Mechanism

The valves and the valve mechanism admit inlet air and release exhaust gases at precisely timed intervals during engine operation.

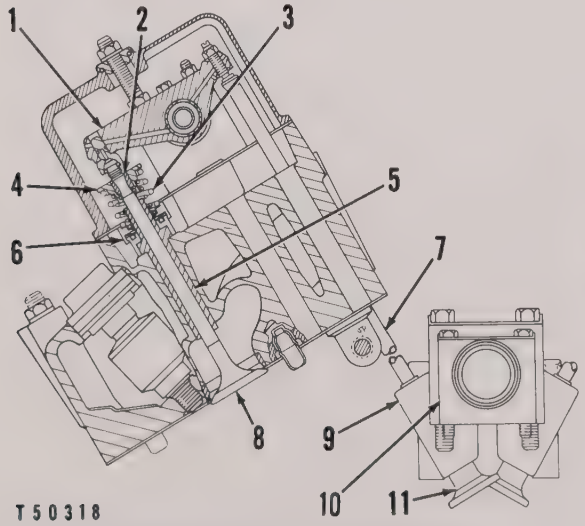
The engine is of the four-stroke cycle, having four separate strokes required for each cylinder to complete one cycle. The camshaft is timed to the crankshaft and turns at one-half engine speed.

The inlet valve is open during the inlet stroke of the piston to permit air to enter the cylinder. After the compression and power strokes, the exhaust valve is opened to permit the piston, in moving up on the exhaust stroke, to force the burned gases from the cylinder.

Properly adjusted valves will operate for many hours before they need to be reconditioned. Eventually, however, the valve faces and seats can become pitted which ultimately allows compression pressure losses.

Valve rotators cause the valves to rotate while the engine is operating. The rate of rotation is approximately three degrees each time the valve is opened.

This rotation decreases the possibility of excessive carbon deposit build up on the valves.



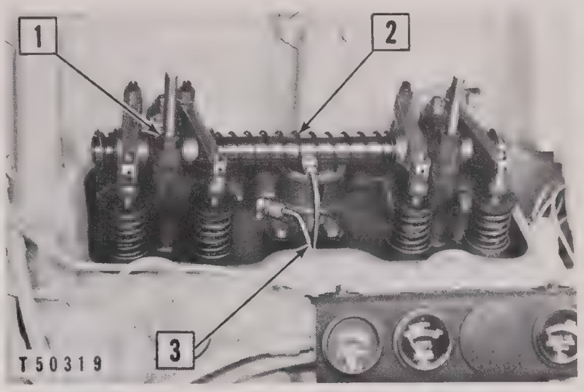
VALVE AND VALVE MECHANISM
(Cross-Section)
1–Rocker arm. 2–Locks. 3–Spring. 4–Retainer. 5–Guide. 6–Valve rotator. 7–Push rod. 8–Valve. 9–Bracket assembly. 10–Connector. 11–Valve lifter.

To determine whether a valve rotator is operating, observe the valve spring retainer. If the retainer does not rotate during operation, replace the valve rotator as a unit.

VALVE ROCKER ARM ASSEMBLY

Removal and Installation

Remove the rocker arm cover.



PREPARING TO REMOVE ROCKER ARM ASSEMBLY

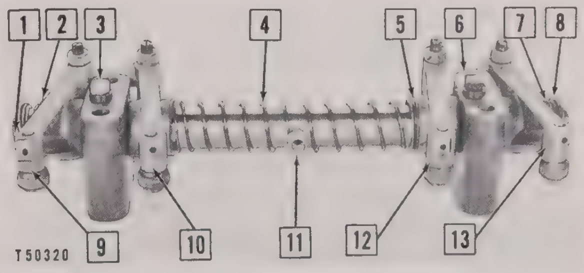
☐ **Remove**

1–Nuts. 2–Rocker arm assembly. 3–Oil line.

NOTE

Whenever the rocker arm assembly is removed from the engine, check the valve clearances and adjust them if necessary on installation. See the topics, SPECIFICATIONS and CHECKING VALVE TIMING.

Disassembly and Assembly



VALVE ROCKER ARM DISASSEMBLY

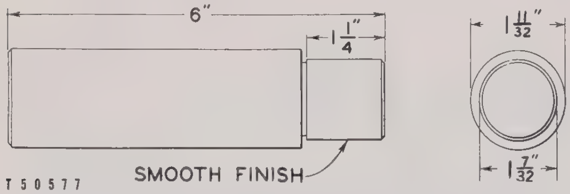
☐ **Remove**

1–Cotter pins. 2–Washers. 3–Bolts. 4–Spring. 5–Washers. 6–Brackets. 7–Spring. 8–Washers. 9, 10–Rocker arms. 11–Fitting. 12, 13–Rocker arms.

The bearings in the rocker arms should be replaced if the clearance between the bearings and the shaft exceeds the value listed in the topic, SPECIFICATIONS.

NOTE

Carefully align the oil holes before the bearing is pressed into place. In order to install new rocker arm bearings properly, a driver similar to the one shown in the sketch should be used.



TOOL FOR INSTALLING ROCKER ARM BEARINGS

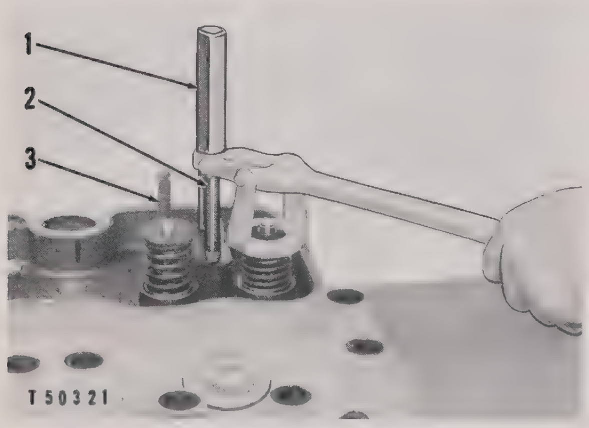
Assemble in the reverse order of disassembly. The supporting brackets should be positioned as shown with the holes for the bolts **(3)** to the left. Be certain the inlet arms **(10)** and **(13)** are installed with the projection (for compression release push rod) toward the exhaust rocker arms **(9)** and **(12)** as illustrated.

VALVES

Removal

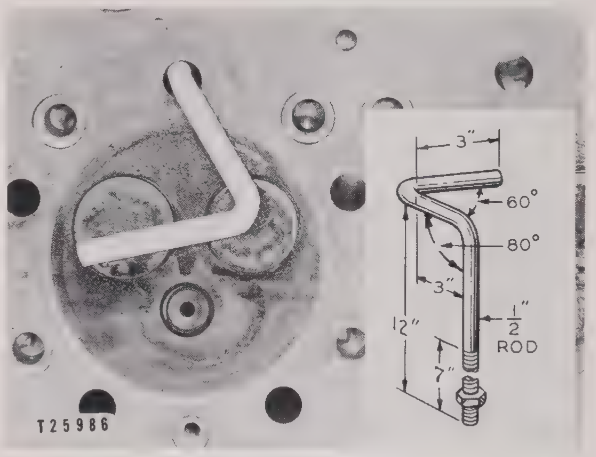
Compress the valve springs and remove the locks. Release the compressor and remove the retainers, springs, and the valve rotators. The valves can now be removed.

The illustration shows the 7F4292 Valve Spring Compressor Group being used. The adapter **(1)**, which is part of this group, threads onto a rocker arm stud **(2)**.



COMPRESSING VALVE SPRING
1–Adapter. 2–Rocker arm stud. 3–Threaded end of valve holding tool.

Also shown is a simple tool which can be made to hold the valves in place while installing the valve springs. The threaded end of this tool, which can also be used on other models of heads, is shown at **(3)**.



VALVE HOLDING TOOL

Cleaning

After removing a cylinder head from the diesel engine and the valve assemblies from the head, carefully scrape all carbon accumulations from the parts. Be sure to clean the valves thoroughly, as well as the valve stems, valve guides and valve ports.

Inspection and Reconditioning

The valves should always be carefully inspected. If the valve faces are pitted or making poor contact with the valve seat, they should be refaced in a valve refacing machine. If the valves are deeply pitted, badly warped or worn they should be replaced.

The wear of the valve stems can be checked by the use of a 0" to 1" micrometer. The valve stem should be measured in three places. Use the measurement near the top of the valve stem, where the valve stem does not touch the guide as the original valve stem diameter.

See the topic, SPECIFICATIONS, for clearances and tolerances.

Checking Valve Seats

Coat the valve face with Prussian blue and rotate the valve in the valve seat. Remove the valve and examine the contact pattern on both valve and seat. A line of contact near the top and around the entire circumference of the valve seat should indicate line contact with the valve.

The valve seats can be ground with a valve seat grinding tool. Care should be exercised in its use, as too much material may be removed quickly and unknowingly

After the valve seats have been ground until they are smooth and concentric with the valve guides, all parts should be cleaned thoroughly.

If the valve seats have been worn or pitted beyond specifications, the valve seat inserts should be replaced. The 7H1970 Valve Insert Puller Group is used for insert removal. Information regarding the tool group is available upon request. Instructions for its use accompany the group.

See the topic, SPECIFICATIONS, for clearances and tolerances.

Valve Installation

Exhaust valves marked "EX" on the valve head should be installed in the exhaust ports; inlet valves marked "IN" on the valve head should be installed in the inlet ports.

Inlet valves have a small groove around the top of the stem for identification after the head has been installed.

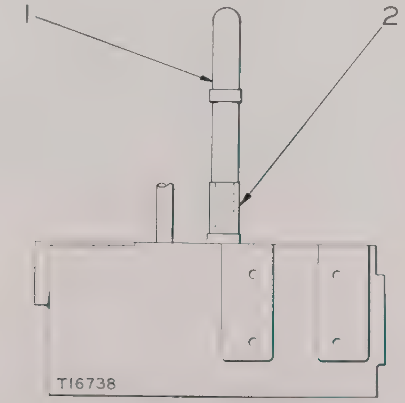
Lubricate the stem and guide for initial starting.

Insert the valve through the valve guide and install the springs and the spring retainer. Compress the springs with a compressor, such as shown in the topic, VALVE REMOVAL. Insert the locks, large end down, and tap the retainer lightly as the spring compressor is removed, to make sure the locks are seated properly in the retainer.

VALVE GUIDES

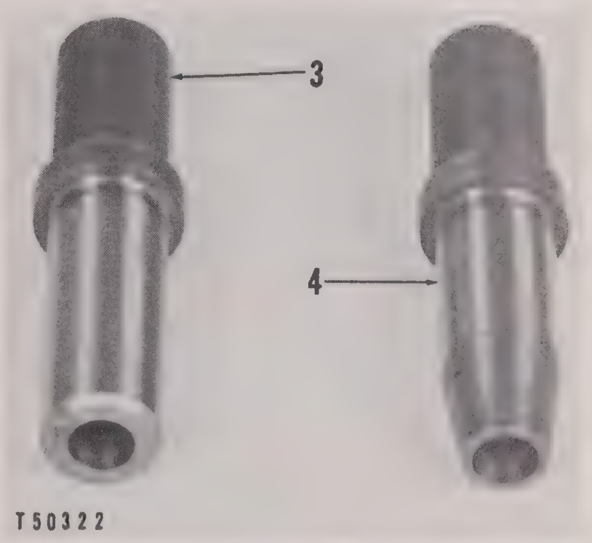
The inlet and exhaust valves operate in replaceable valve guides. After the valves have been removed, clean the valve stems and valve guides.

The valve guide wear should be checked with a gauge or by the pilots furnished with some makes of valve seat regrinding equipment. Generally, the pilots are supplied in graduated sizes. Use a micrometer to measure the diameter of the largest pilot that will pass through the guide. This dimension will indicate the wear in the guide excluding the out-of-roundness.



INSTALLING VALVE GUIDES
1–4H446 Driver. 2–Valve guide.

The valve guide **(2)** can be pressed out of the head using the driver **(1)**. The inlet valve guide **(4)** can be identified by the tapered end while the exhaust valve guide **(3)** is straight.



VALVE GUIDES
3–Exhaust valve guide. 4–Inlet valve guide.

The guides should be pressed into place carefully with the driver **(1)**. A reamer run through the guides after they are installed will insure correct valve stem clearance. See the topic, SPECIFICATIONS, for clearances and tolerances.

VALVE TIMING

The valve timing is controlled by the setting of the camshaft gear with the crankshaft rear gear. Corresponding marks on these two gears must be aligned before installing the flywheel housing. These marks are described in the topic, CAMSHAFT AND CAMSHAFT GEAR INSTALLATION.

Checking Valve Timing

If it is suspected that the valve timing is incorrect, the flywheel of the engine can be used for checking valve timing.

1. Turn the flywheel in the direction of normal engine rotation to top dead center for the piston as indicated by the timing mark stamped on the flywheel. If the flywheel is turned past the timing mark, turn it back about 60° and again

bring it up to the top dead center mark on the compression stroke.

NOTE

These timing marks are visible through the inspection cover located on the flywheel housing.

2. Set the valve clearance according to the figure given in the topic, SPECIFICATIONS.
3. Turn the engine over slowly until the inlet valve is off its seat .075″.
4. Make a new mark on the flywheel.
5. Measure the distance between the marks and convert to degrees by the following formula.

$$\text{Degrees} = \frac{\text{Distance between marks}}{\text{Pulley diameter} \times 3.1416} \times 360$$

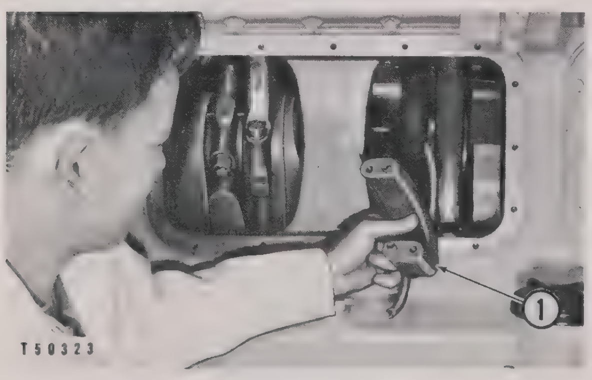
Compare the answer with valve timing information given in the topic, SPECIFICATIONS.

VALVE LIFTERS

The valve lifters operate in brackets which are attached to the engine block by bolts and locks under the fuel pump and governor drive housings in the V of the engine. The lifters follow the contour of the camshaft lobes and raise the push rods so that valves open and close in the specified order.

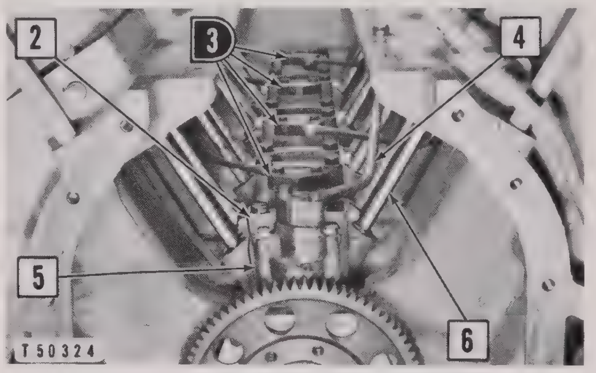
Valve Lifter Removal and Installation

1. Remove the inspection covers from the side of the engine and remove the spray tube **(1)** bolted to the bottom of the lifter.



REMOVING SPRAY TUBES
1–Spray tubes.

2. Remove the valve rocker arm covers and remove the rocker arm assembly. See the covering topic.
3. Remove the fuel pump and governor drive housing from the V of the engine. See the covering topic.

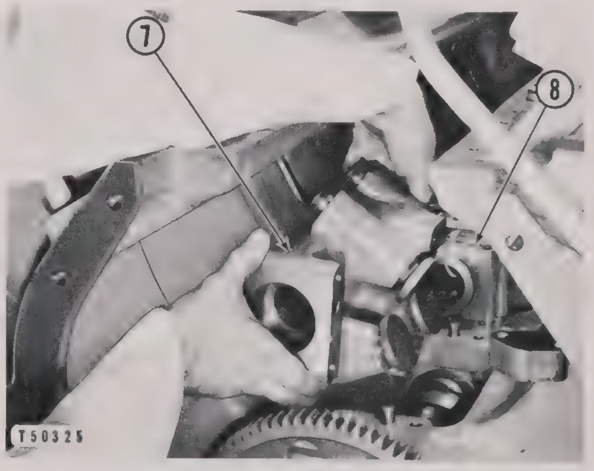


PREPARING TO REMOVE VALVE LIFTERS AND BRACKETS
(Flywheel Housing Removed for Better Illustration)

☐ **Remove** ◗ **Disconnect**

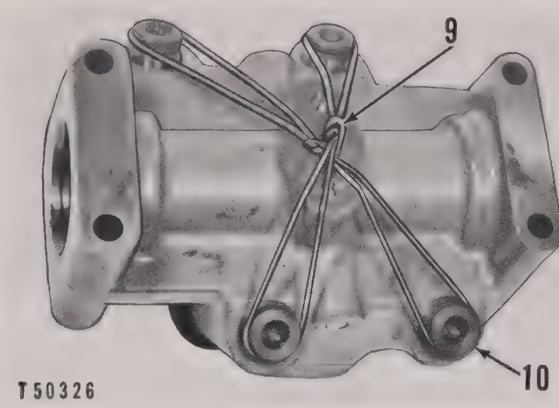
2–Lifter brackets. 3–Rocker arm oil lines. 4–Fuel pump and governor drive lube line. 5–Elbow. 6–Push rods.

4. Place a wire or large rubber band **(9)** around the lifters **(10)** to hold them in place in the bracket.
5. Remove the bolts and locks securing the bracket assembly to the engine block and remove the bracket and lifters **(7)** as shown.



REMOVING BRACKET AND LIFTERS
(Flywheel Housing Removed for Better Illustration)
7–Bracket and lifters. 8–Connector.

6. The connector **(8)** between each bracket can be pushed into the adjoining bracket after removing the bolts securing it to the engine block. The brackets are positioned with two dowel pins and must be lifted straight up to remove them.



LIFTERS HELD IN BRACKET
9–Rubber band. 10–Lifters.

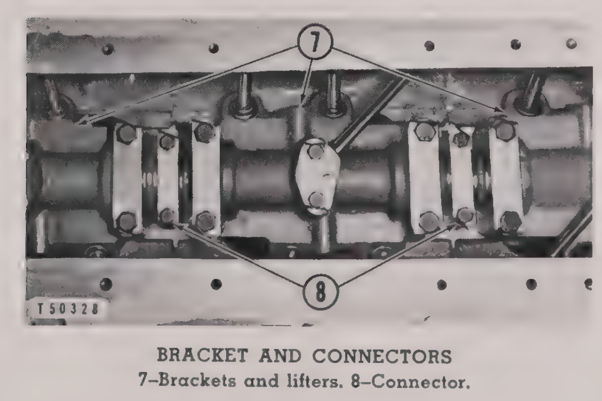
NOTE

Inspect the valve lifters and brackets for wear. If the clearance between the lifter and the bracket exceeds the value given in the topic, SPECIFICATIONS, the lifter or bracket or both should be replaced. If the face of the lifter is damaged, inspect the lobes of the camshaft. Replace the camshaft if necessary.

7. Install in the reverse order of removal, replacing all gaskets and O-ring seals.

NOTE

Any of the individual bracket assemblies can be removed independently of the others. Remove the bolts from the connectors **(8)** on either side of the bracket to be removed and slide the connectors into the adjacent brackets as far as possible. The bracket and lifters **(7)** can then be reremoved.

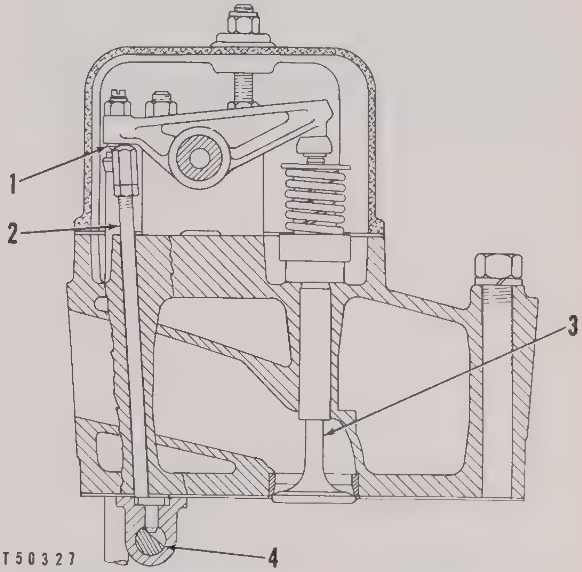


BRACKET AND CONNECTORS
7–Brackets and lifters. 8–Connector.

COMPRESSION RELEASE MECHANISM

The compression release mechanism opens the inlet valve on each cylinder, allowing the diesel engine to be cranked more easily.

The compression release shaft **(4)** can be locked in either the RUN or START position. When moved to the START position, the compression release shaft forces the push rods **(2)** against the inlet valve rocker arms **(1)**, holding the inlet valves **(3)** open. In the RUN position, the flat portion of the compression release shaft **(4)** permits normal valve operation.

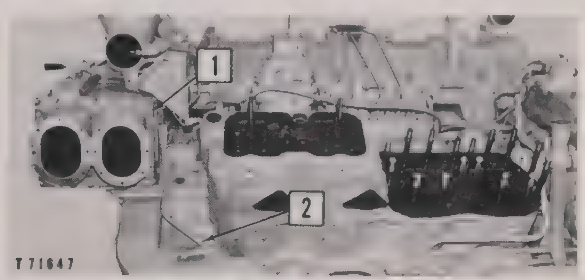


COMPRESSION RELEASE MECHANISM
1–Inlet valve rocker arm. 2–Compression release push rod. 3–Inlet valve. 4–Compression release shaft.

The compression release clearance adjustments is provided at the upper end of the push rods **(2)**. For the proper clearance between the rocker arms and the push rods, see the topic, SPECIFICATIONS.

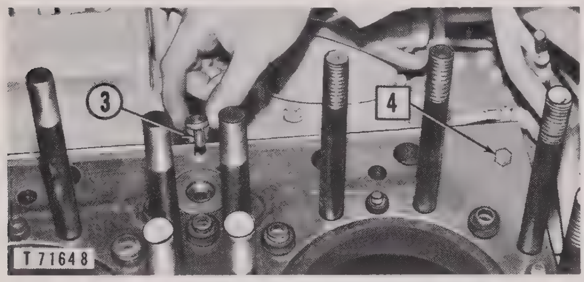
Removal and Installation

1. Remove air cleaner assembly.
2. Remove turbocharger and related pipes.
3. Remove inlet and exhaust manifolds.
4. Remove the valve covers, rocker arm assemblies, push rods and compression release adjustment rods.



PREPARING TO REMOVE COMPRESSION RELEASE SHAFT
1–Aftercooler cover. 2–Turbocharger lubrication line.

5. Remove the cylinder heads. (D379—front head on right bank, rear head on left bank. D398—middle head on both banks).

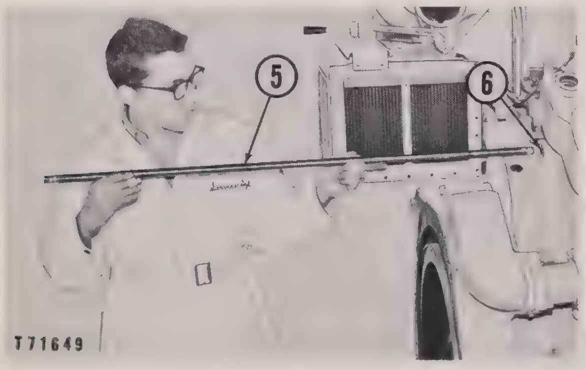


PREPARING TO REMOVE COMPRESSION RELEASE SHAFT
3–Pawl. 4–Bolt.

NOTE

Bolt **(4)** positions the compression release shaft laterally. Pawl **(3)** prevents the shaft from rotating too far but it also limits lateral movement of the compression release shaft.

6. Remove pawl **(3)**.
7. Remove compression release shaft **(5)**.



REMOVING COMPRESSION RELEASE SHAFT
5–Compression release shaft. 6–Seal.

NOTE

The shaft can be removed at the front of the engine by removing the oil filter housing. The oil seals **(6)**, one at each end of the cylinder block, are usually damaged when removing and installing the compression release shaft.

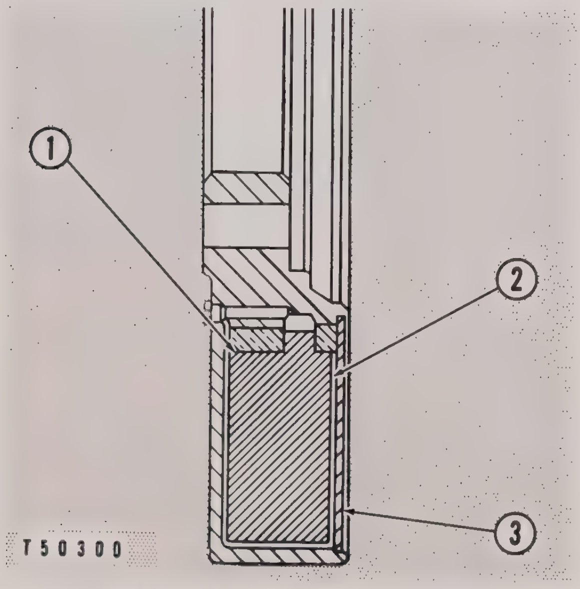
8. Before installing compression release shaft **(5)**, remove seals **(6)**.
9. Install the compression release shaft.
10. Install new seals **(6)**, with the lips to the inside of the cylinder block. Use care not to damage the seal lips.

Vibration Damper

A vibration damper counteracts torsional vibrations that occur within the operating speed range of the engine.

When an engine is running, the crankshaft twists back and forth about its axis due to the regular pattern of power impulses imposed along its length. This twisting of the crankshaft is called torsional vibration. A vibration damper installed on the end of the crankshaft opposite the flywheel helps to reduce torsional vibration and prevents it from building up to harmful proportions.

The damper is constructed of a solid cast iron weight **(1)** enclosed in a metal case **(3)**. The small space **(2)** between the case and weight is filled with a viscous fluid that permits the iron weight to move in such a manner within the case as to damp the vibrations of the crankshaft.



VIBRATION DAMPER CROSS SECTION
1–Sold cast iron weight. 2–Space between case and weight. 3–Case.

If the case becomes dented, the viscous fluid may partially solidify or the case and iron weight may actually rub against each other. In either instance it will restrict the movement of the iron weight; and instead of damping crankshaft vibrations and reducing gear train noise, it may actually increase vibrations that could result in crankshaft failure. It will, in most cases, cause excessive gear train noises.

A viscous type damper that is operating correctly absorbs energy to damp out torsional vibrations and becomes much warmer than the surrounding engine parts. A damper that is not operating correctly will remain at only about 10° to 15° above ambient air temperature. Therefore, by feeling the damper after at least one hour of engine operation, faulty damper can be detected.

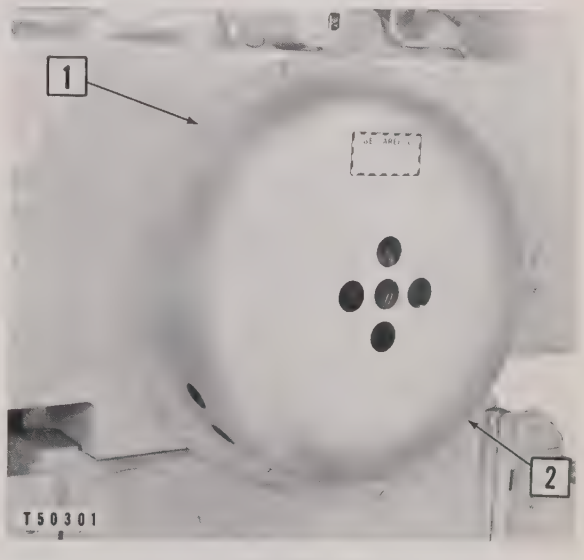
Avoid welding, hammering or prying on the damper case. A damper that has the mounting holes worn oblong should be replaced.

The damper should be checked occasionally for dents or bulges in the damper case, and to see that the damper to hub mounting bolts are tight. A dented or bulged case requires that the damper be replaced. Damage can occur to the damper, the hub, and to the crankshaft if the engine is operated with the damper to hub mounting bolts loose.

Whenever a damper is found to be defective, it should be replaced.

DAMPER REMOVAL AND INSTALLATION

1. Remove the fan group and radiator, if so equipped.



COVER REMOVAL

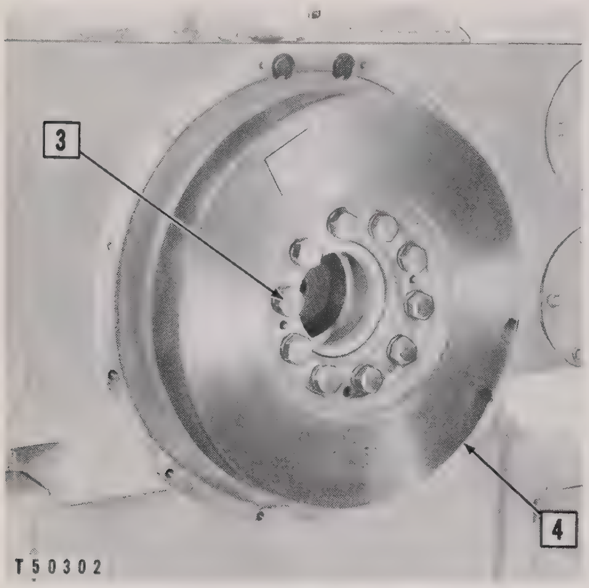
☐ Remove

1–Bolts. 2–Cover.

2. Install a 3/4"-10 (NC) guide pin **(5)**, 8 inches long and two 1/2"-13 (NC) forcing screws **(6)** in the vibration damper **(4)**.
3. Using the forcing screws **(6)**, force the vibration damper **(4)** out on the guide pin **(5)** until a suitable hoist can be attached and the vibration damper removed.

NOTE

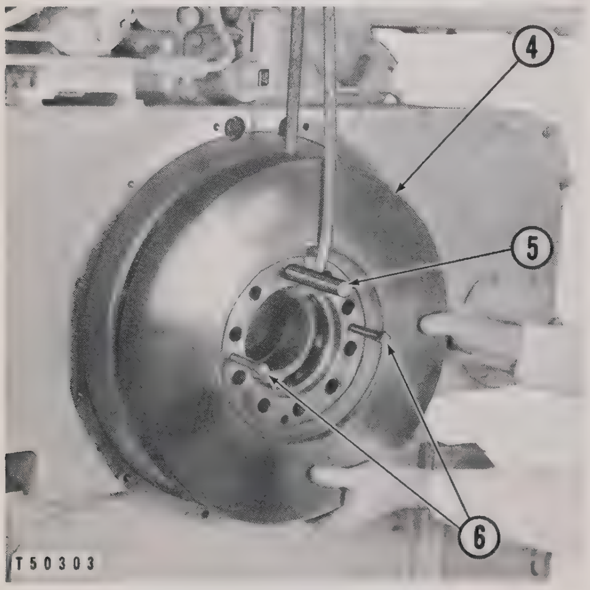
The damper is a single unit requiring no service. If it is damaged, it must be replaced.



PREPARING TO REMOVE THE VIBRATION DAMPER

☐ Remove

3–Bolts. 4–Vibration damper.



VIBRATION DAMPER REMOVAL
4–Vibration damper. 5–Guide pin. 6–Forcing screws.

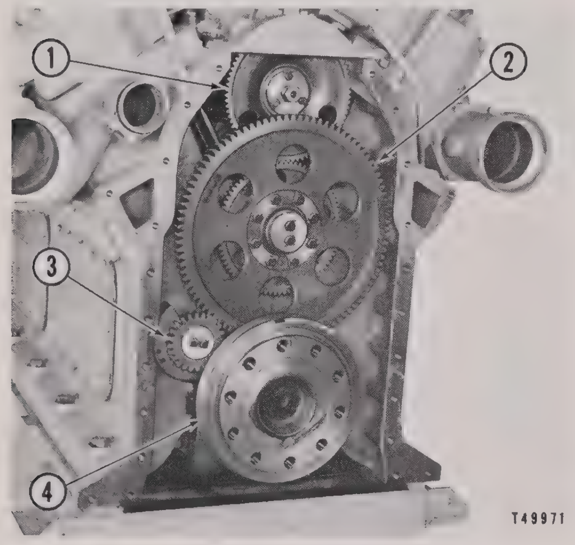
4. When installing the damper, tighten the bolts to the proper torque value. See the topic, SPECIFICATIONS.

CAUTION

Damage can occur to the damper and to the crankshaft if the engine is operated with the damper to crankshaft mounting bolts loose.

Timing Gears

The timing gears are located at the rear of the engine and are encased within the cylinder block using the front face of the flywheel housing as a cover. The timing gears keep the rotation of the crankshaft, camshaft, balancers if so equipped, and the governor drive gear in the correct relationship to each other. A gear integrally cut on the rear of the crankshaft drives the timing gears.



TIMING GEARS
(D379 Illustrated)
1–Governor drive gear. 2–Camshaft cluster gear. 3–Balancer gear. 4–Crankshaft gear.

The crankshaft gear **(4)** drives the camshaft cluster gear **(2)** which in turn drives the balancer gear **(3)** and governor drive gear **(1)**. The camshaft cluster gear is keyed to the camshaft.

NOTE

The D398 engines do not use balancers, therefore the balancer gear **(3)** would not be used.

CAMSHAFT

The camshaft rotates in bearings located in the V of the engine. It is driven by a gear on the rear of the crankshaft. The camshaft is positioned by a thrust washer secured to the face of the cylinder block which fits in a groove in the camshaft cluster gear. The cams which actuate the inlet and exhaust valves are forged integrally with the camshaft.

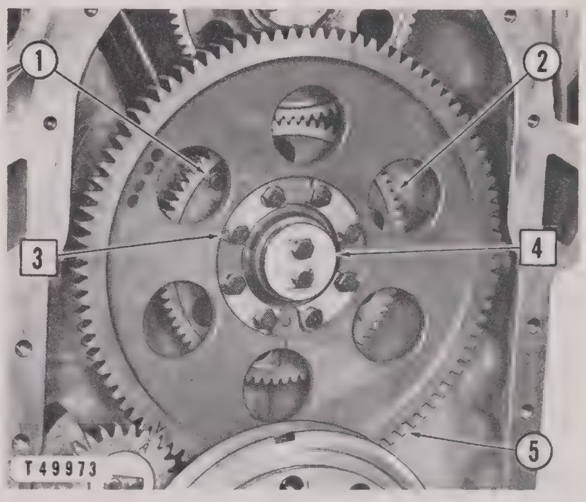
Camshaft Cluster Gear Removal

1. Position the engine with No. 1 piston at a top center on the compression stroke. Use the procedure outlined under the topic, TIMING THE FUEL INJECTION PUMP CAMSHAFT.

NOTE

On natural gas engines, see the topic, TIMING THE MAGNETO AND GOVERNOR DRIVE.

2. Remove the flywheel housing. See the covering topic.

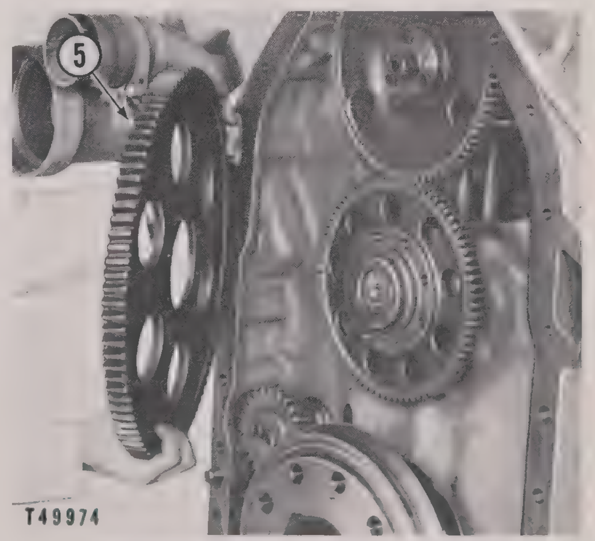


PREPARING TO REMOVE CAMSHAFT CLUSTER GEAR
☐ **Remove**
1–Bolt and lock. 2–Small cluster gear. 3–Bolts (eight). 4–Retainer. 5–Large cluster gear.

3. Remove the large cluster gear **(5)** as shown.

CAUTION

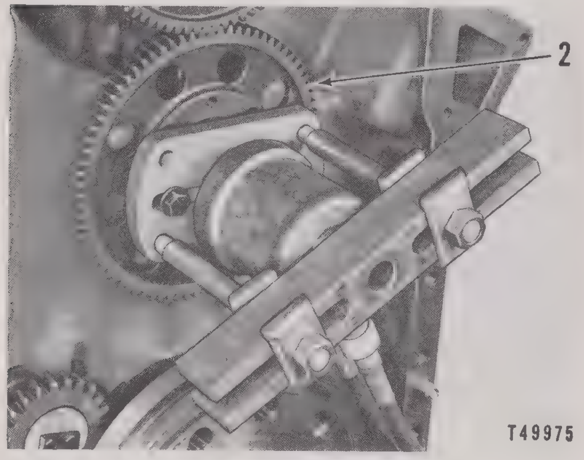
To avoid piston and valve interference, do not rotate the crankshaft with the large camshaft cluster gear removed and the camshaft installed.



LARGE CLUSTER GEAR REMOVAL
5–Large cluster gear.

4. Remove the bolts and locks **(1)**, which secure the thrust washer to the cylinder lock, through the holes in the small cluster gear **(2)** and remove the thrust washer.

5. Remove the small cluster gear **(2)** using a 7F9540 Hydraulic Puller, an 8F3672 Puller Plate with an 8B7548 Push Puller and a suitable spacer as illustrated. Remove the key from beneath the gear.



SMALL CLUSTER GEAR REMOVAL
2–Small cluster gear.

6. Inspect all parts for wear or damage and replace if necessary. See the topic, SPECIFICATIONS, for the correct clearances and dimensions.

Camshaft Cluster Gear Installation

1. Install the small cluster gear **(2)**, the thrust washer and the retainer **(3)**, tightening the bolts which secure the retainer to the torque listed in the topic, SPECIFICATIONS.
2. Install the large cluster gear **(1)**, aligning the C-mark on the gear with the punch marked tooth on the crankshaft gear by looking through the hole in the crankshaft flange as illustrated.

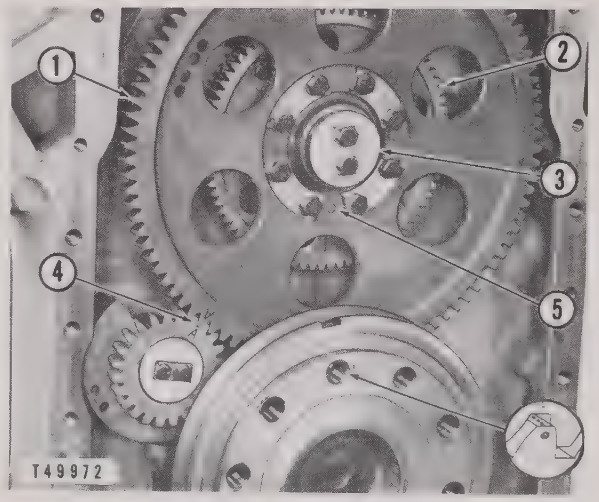
NOTE

Make certain the engine is positioned with the No. 1 piston at top center of the compression stroke.

NOTE

A chalk mark on the large cluster gear over the C-mark and a chalk mark on the punched tooth will help in aligning the teeth.

3. Tilt the large cluster gear and rotate the balancer gear until the A-marks **(4)** line up.

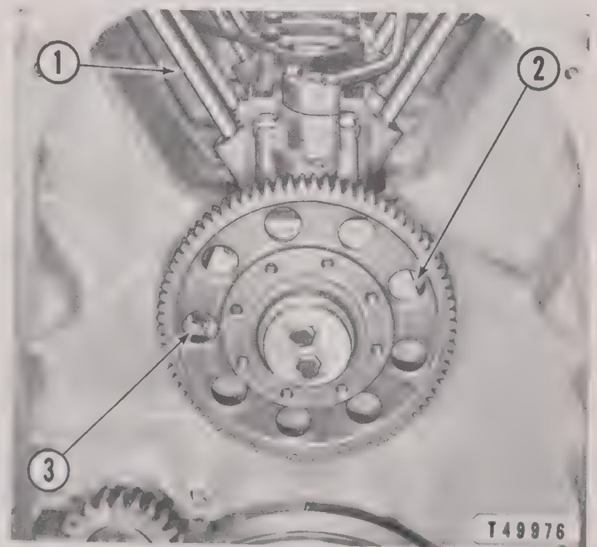


INSTALLING CLUSTER GEAR
1–Large cluster gear. 2–Small cluster gear. 3–Retainer. 4–A-marks. 5–Dowel.

4. With the timing marks aligned, slide the large cluster gear over the dowel **(5)** in the small cluster gear and install the mounting bolts.

Camshaft Removal and Installation

1. Remove the fuel pump and governor drive housing or, on natural gas engines, the magneto and governor drive housing. See the covering topics.
2. Remove the flywheel housing and the service meter and drive assembly. See the covering topics.
3. Remove the large cluster gear from the camshaft. See the topic, CAMSHAFT CLUSTER GEAR REMOVAL.

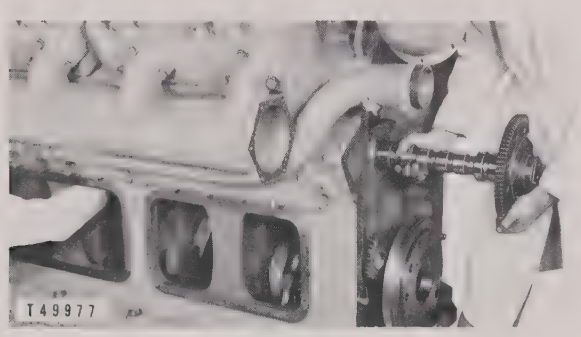


PREPARING TO REMOVE CAMSHAFT
1–Push rods. 2–Thrust washer. 3–Bolt and lock.

4. Remove the push rods **(1)**. See the topic, VALVE ROCKER ARM REMOVAL AND INSTALLATION.
5. Hold the valve lifters off the cam lobes as described in the topic, VALVE LIFTER REMOVAL.
6. Remove the bolts and locks **(3)** that secure the thrust washer **(2)** to the cylinder block and remove the thrust washer.
7. Remove the camshaft as illustrated.

NOTE

One end of the camshaft is stamped with an F-mark to insure correct installation of the cluster gear. On counterclockwise rotation engines, install the cluster gear on the end opposite the F-mark. On clockwise rotation engines, install this gear on the end with the F-mark.

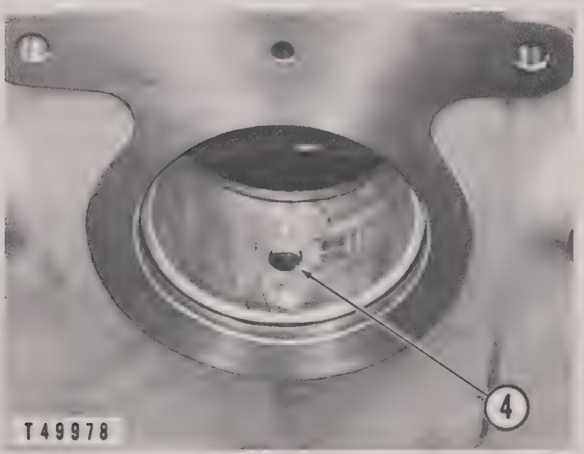


CAMSHAFT REMOVAL

8. Inspect the camshaft and camshaft bearings for wear or damage and replace if necessary. See the topic, SPECIFICATIONS, for the correct clearances and tolerances.

NOTE

If the camshaft bearings are to be replaced it will be necessary to remove the valve lifters.



OIL HOLE IN BEARING
4–Oil hole.

9. Align the oil hole **(4)** in the bearing with the oil passages in the block if the bearings are replaced.
10. Install the camshaft and camshaft cluster gear. See the topic, CAMSHAFT CLUSTER GEAR INSTALLATION, for information on timing the cluster gear.

Front Accessory Drive

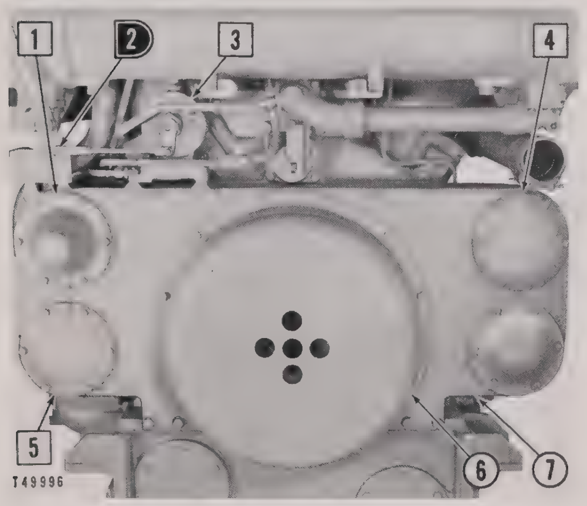
The front accessory drive provides up to five splined drives for accessories such as a charging generator, raw water pump, air compressor and hydraulic pump, in addition to the oil pump and water pump. An extension of the water pump shaft provides another convenient auxiliary drive.

Oil under pressure provides lubrication for the shaft bearings and gears. An oil thrower and piston ring type seal prevent leakage between the crankshaft and accessory drive housing. The lubricating oil drains into the front scavenge sump of the oil pan base.

FRONT ACCESSORY DRIVE HOUSING

Removal and Installation

1. Remove any accessories that are attached to the front of the accessory drive housing.



PREPARING TO REMOVE THE ACCESSORY DRIVE COVER

☐ Remove ◗ Disconnect

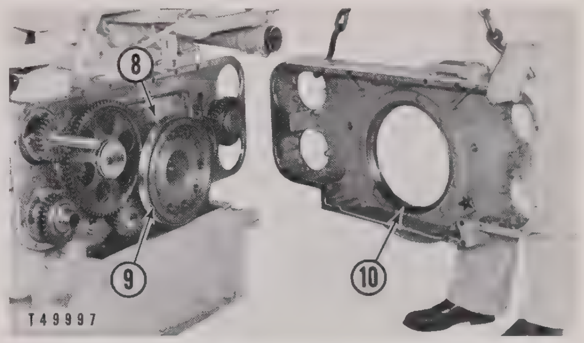
1–Bearing retainer and cover. 2–Fuel priming pump linkage. 3–Priming pump. 4–Covers (four). 5–Bearing retainer. 6–Crankshaft cover. 7–Accessory drive housing.

2. Remove the cover **(6)** and remove the adapter and shield on the end of the crankshaft.

NOTE

On the D398 Engine, the vibration damper is attached to the adapter. Remove the damper, adapter and shield.

3. Attach a suitable hoist to the accessory drive housing **(7)** and remove the bolts securing the housing to the plate and block.
4. Remove the housing as illustrated.



REMOVING THE ACCESSORY DRIVE COVER
(D379 Illustrated)
8–Thrower. 9–Piston ring seal. 10–Baffle.

5. Inspect the baffle **(10)** and replace if worn or damaged. Nicks and burrs should be removed from the chamfered edge to prevent damage to the piston ring seal **(9)** during installation.
6. To install the accessory drive housing, back off the bolts securing the engine block to the oil pan base. Remove the bolts securing the oil pump assembly to the oil pan base.
7. Loosen the bolts holding the oil pan base to the engine. Raise the front of the engine approximately 3/8" and insert spacers between the engine block and oil pan base.
8. Inspect the gaskets and replace if damaged.
9. Install the accessory drive housing.

NOTE

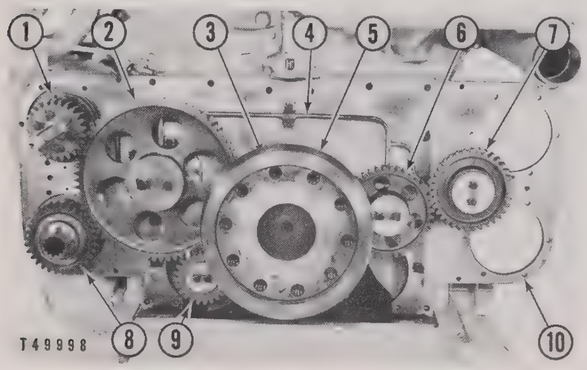
The leading edge of the baffle **(10)** is chamfered so that the piston ring seal **(9)** will compress in its groove and center in its bore during installation.

10. Remove the spacers from between the oil pan base and the engine block and tighten the bolts. Replace the bolts in the oil pump assembly.

Disassembly and Assembly

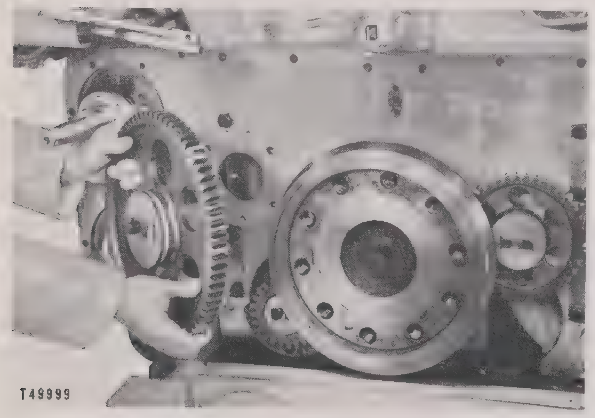
1. Remove the bolts and locks from the water pump drive gear **(1)** and remove it from the shaft.
2. Remove the retaining washer from the idler gear **(7)** and remove the gear from the stub shaft. Remove the stub shaft.
3. The oil pump drive gear **(8)** is splined to the oil pump drive shaft. Remove the gear.

4. Remove the tube assembly **(4)**. The crankshaft can be rotated to gain access to the bolts securing the end of the tube assembly.



ACCESSORY DRIVE GEARS
(D379 Illustrated)
1–Water pump drive gear. 2–Main idler gear. 3–Crankshaft gear. 4–Tube assembly. 5–Thrower. 6, 7–Idler gears. 8–Oil pump drive gear. 9–Balancer gear. 10–Plate.

5. The main idler gear **(2)** and its stub shaft can be removed by rotating the crankshaft to gain access to the bolts securing the stub shaft to the engine block and plate **(10)**.



REMOVING THE MAIN IDLER GEAR
(D379 Illustrated)

6. Remove the idler gear **(6)** and the stub shaft as a unit. The crankshaft can be rotated to gain access to the bolts and locks securing the stub shaft to the plate.

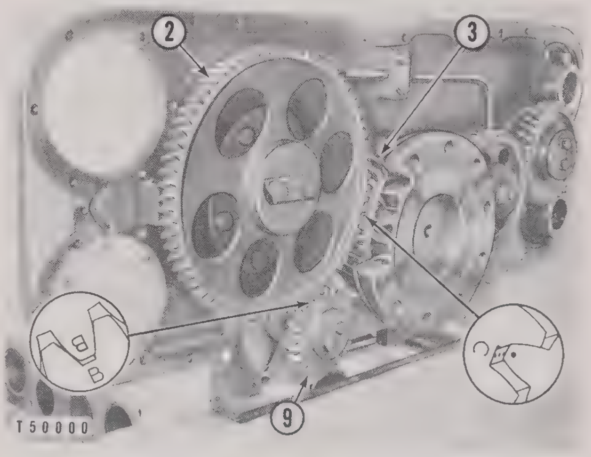
NOTE

Remove the retainers from the gears **(2)** and **(6)** and inspect the bearings and stub shafts. Replace the bearings in gears **(2)**, **(6)** and **(7)** if the maximum clearance is greater than the maximum permissible clearance given in the topic, SPECIFICATIONS.

7. If it is necessary to remove or replace the thrower **(5)**, see the topic, CRANKSHAFT.

NOTE

Accessory drive gear trains are identical on both the D379 and D398 except for the weighted balance gear **(9)** used on the D379. The balance gear "B" timing mark must be aligned with the "B" on the main idler gear **(2)** and the "C" on the main idler gear must be aligned with the punch marked tooth on the crankshaft gear **(3)**. On the D398 engines, a vibration damper is mounted on the front of the crankshaft and no timing is necessary on the accessory drive gears.



TIMING THE MAIN IDLER AND BALANCER
(D379 Illustrated)
2–Main idler gear. 3–Crankshaft gear. 9–Balancer gear.

8. Complete the assembly of the accessory drive gears in the reverse order of disassembly.

NOTE

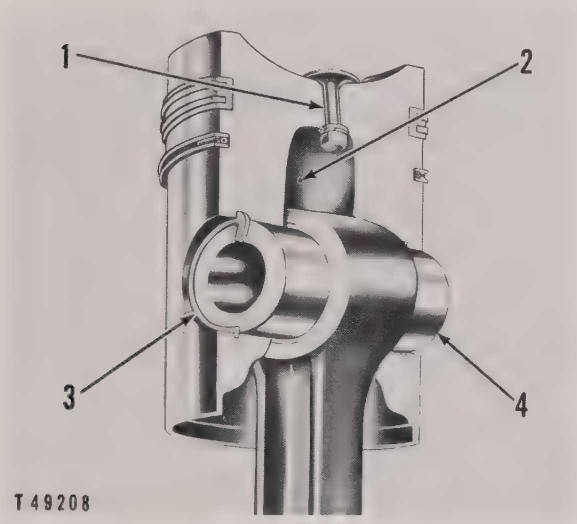
Later engines do not use gaskets between either tube assembly **(4)** or the idler gear stub shafts and plate **(10)**. Earlier engines do have these gaskets but they can be omitted at installation. When installing either the stub shafts or the tube assembly, always use 7M7260 Liquid Gasket. Later engines also use lockwashers with the bolts while earlier engines use sheet metal locks and rubber seal washers that can be replaced with lockwashers and new bolts. When lockwashers are used with bolts always apply either grade AV Loctite or an equivalent compound to the threads and increase bolt tightening torque. Correct bolt tightening torque values to use are: 5/16 in., 22-28 lb. ft.: 3/8 in., 36-44 lb. ft: 1/2 in., 85-95 lb. ft.

Piston, Rings and Connecting Rods

PISTONS AND RINGS

The aluminum alloy piston has three rings, consisting of two compression rings and one oil ring. All rings are located above the piston pin bore. The two compression rings seat in an integral cast iron band and the single oil ring is spring loaded. Holes **(2)** in the groove for the oil ring provide for the return of oil to the crankcase.

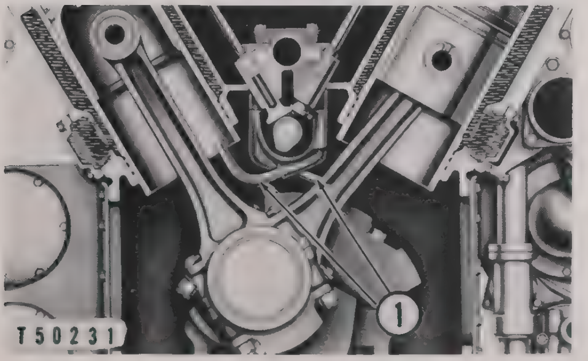
The full floating piston pin **(4)** is retained by two snap rings **(3)** which fit in grooves in the pin bore.



PISTONS AND RINGS
1–Heat plug. 2–Oil return hole. 3–Snap ring. 4–Piston pin.

The stainless steel plug **(1)** in the crater of the piston prolongs piston life by providing a more heat resistant surface at the point of highest combustion temperature.

PISTON AND RING LUBRICATION



POSITION OF SPRAY TUBE
1–Spray tubes.

The pistons, the rings and the cylinder liners are lubricated by the oil that is thrown by the crankshaft while the engine is in operation.

Oil return holes in the piston oil ring groove provide for the return of oil to the crankcase.

The pistons are cooled and the piston pins are lubricated by spray tubes **(1)**, positioned in the cylinder block under each cylinder liner. A drilled passage connects the spray tubes directly to the oil manifold. Each spray tube assembly has two tubes which spray oil on pistons opposite each other in the block. Each tube assembly is held by two bolts, one on each side of the camshaft. They are accessible through the inspection openings in the side of the cylinder block.

PISTONS

Removal and Installation

1. Move the compression release lever to the START position.
2. Remove the oil cooler and lines, oil pump, turbocharger lubrication valve and the water pump. See the covering topics.
3. Remove the bolts and lockwashers securing the inspection covers and remove the covers and gaskets.
4. Disconnect the connecting rod from the crankshaft. See the topic, CONNECTING ROD BEARING REMOVAL.
5. Move the piston and rod down until the piston pin and snap ring are visible but not so far as to allow the rings to slip out of the cylinder liner.

NOTE

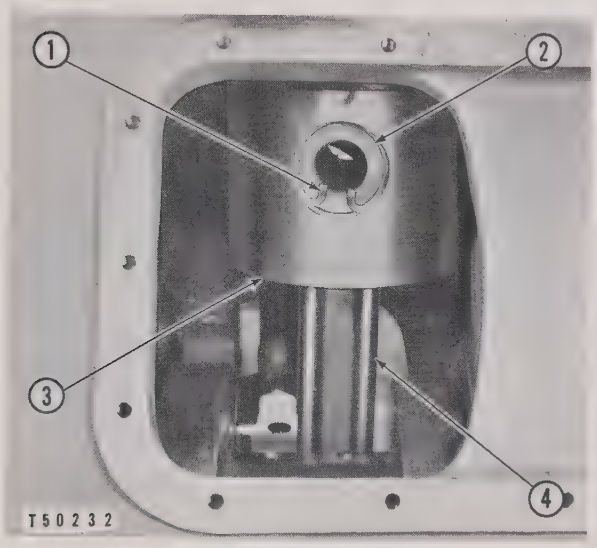
The crankshaft must be rotated away from the connecting rod or both rods must be disconnected from the rod journal of the crankshaft to obtain enough clearance to move the rod and piston down.

6. Remove the snap ring **(1)** and piston pin **(2)** after rotating the piston **(3)** 90° in the cylinder liner. Support the connecting rod **(4)** so it will not fall.

NOTE

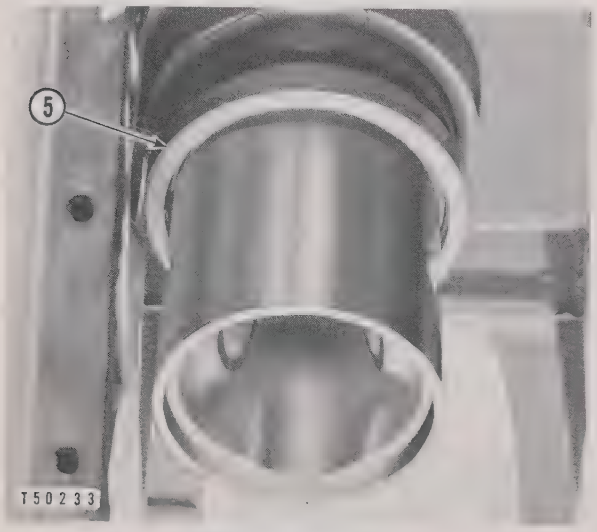
Inspect the snap ring for wear upon removal from the piston. If the snap ring fits snugly, it can be reused. If not, replace it upon installation.

7. Move the piston into the liner and remove the connecting rod.



SNAP RING AND PISTON PIN REMOVAL
1–Snap ring. 2–Piston pin. 3–Piston.
4–Connecting rod.

8. Remove the piston from the cylinder. Clean and lubricate the cylinder wall, the piston and the piston rings with clean lubricating oil.
9. Using the piston ring compressor **(5)**, install the piston as shown. Keep the upper face of the ring compressor tight against the cylinder liner.



PISTON INSTALLATION
5–6H4140 Piston Ring Compressor.

10. Remove the ring compressor after the piston is inserted in the liner and install the remaining parts in the reverse order of removal.
11. Position the connecting rods and caps as indicated in the topic, CONNECTING RODS, and install.

NOTE

Upon installation of the connecting rod, align the V-mark on the piston skirt so that it faces outward from the bank of cylinders in which it is installed. This will place the piston crater and the valve recesses in their proper positions.

Cleaning and Inspecting Piston

Pistons which are not worn excessively or scored badly should be cleaned and used again. The ring grooves should be square and smooth. For permissible side clearance, see the topic, SPECIFICATIONS.

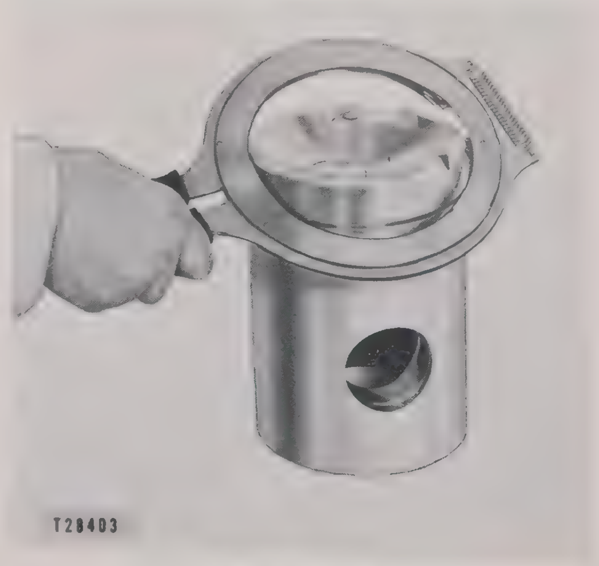
There are a number of good carbon solvents available for cleaning pistons. A carbon softener for use on diesel engine pistons is fresh, cold water. Soak pistons in cold water overnight, let them dry (preferably in sunlight) and most of the carbon including that in the ring grooves can be easily rubbed off.

The use of broken rings or carbon scrapers on ring grooves should be avoided, as the grooves can be cut. A stick of hard wood does a good job and will not scratch the piston.

The bottom of each ring groove must be clean and the oil return holes in the oil ring groove must be open before the installation of new rings.

The area above the top ring can be filed smooth, but pistons badly scored below the top ring groove should be replaced.

RINGS



RING EXPANDER

Piston rings seal compression and control the amount of oil on the cylinder walls. If oil consumption is not excessive and compression is satisfactory, pistons should not be removed nor new rings installed when an engine is dismantled for some other reason.

To avoid damage to the piston, remove the rings with a 5H9621 Ring Expander.

The rings should be placed on the piston in the proper groove. Use the 5H9621 Piston Ring Expander when placing the rings in the grooves. The ring expander is not only a time saver but will also prevent breaking or distorting rings and damaging ring grooves.

For the ring gap of a new ring in a new liner, see the topic, SPECIFICATIONS.

CAUTION

The intermediate compression ring has the TOP marked. Be sure to install this ring correctly.

When new piston rings are to be used in worn cylinder liners, the ridge at the top of the liner should be raised as recommended in the topic, RECONDITIONING CYLINDER LINERS.

Whenever new rings, piston assemblies or piston and liner groups are installed, be sure to run-in the engine on a conditioning schedule before operating at normal load and speed. Do not run the engine idle for a long period after installing new rings or liners. Rings will not seat during idle operation. See the topic, RUNNING-IN SCHEDULE.

RUNNING-IN SCHEDULE

For the correct running-in procedures, follow the information that accompanies piston rings, piston assemblies and piston and liner groups sent from the Caterpillar Parts Department.

CONNECTING RODS

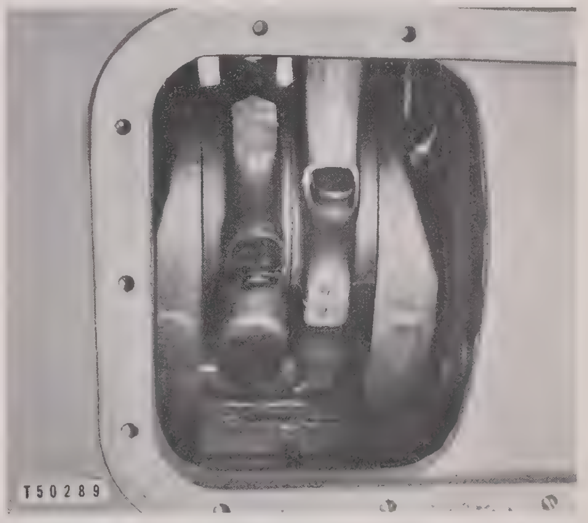
The bearing caps and rods are numbered consecutively, from the front of the engine on the outside so that the numbers can be seen through the inspection openings in the sides of the cylinder block. The rods must be reassembled with the numbers in this position, with the odd numbers visible on the right side of the engine, the even numbers on the left. For removal and installation of the connecting rods, see the topic, PISTONS.

CONNECTING ROD AND PISTON PIN

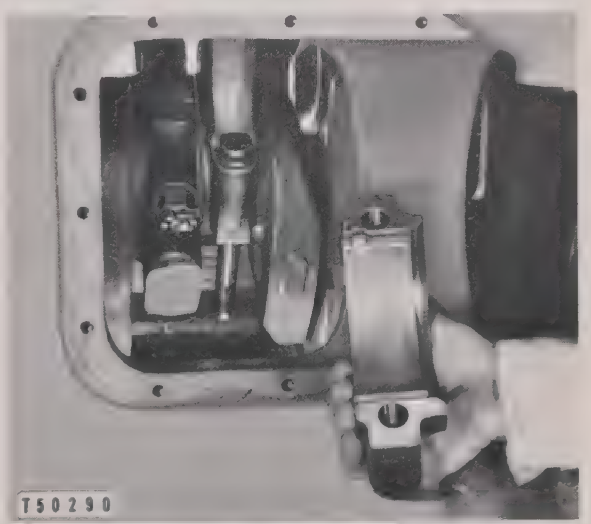
Connecting Rod Bearing Removal

Connecting rod bearings are the precision type and are to be installed without fitting or scraping. The bearing halves can be removed, inspected and replaced through the inspection openings without removing the rod from the engine.

To remove a connecting rod bearing through the inspection opening, remove the cover and turn the crankshaft until the bearing to be removed is in the position shown in the illustration.



PREPARING TO REMOVE CONNECTING ROD CAP



REMOVING CONNECTING ROD BEARING CAP

Remove the cotter pins and the nuts from the connecting rod bolts with a 7F9303 Wrench and take out the cap and lower half of the bearing.

Rotate the crankshaft away from the rod or push the rod up slightly and remove the upper half of the connecting rod bearing.

Connecting Rod Bearing Inspection

Connecting rod bearings are steel-backed, aluminum-lined. Larger particles of dirt and abrasives in the oil do not tend to embed in aluminum bearings. Such particles roll around between the bearing and crankshaft journal causing scratches in the aluminum bearing without actually becoming embedded in the aluminum. Such scratches are not necessarily harmful and do not indicate that the bearings should be replaced.

For permissible bearing clearance, see the topic, SPECIFICATIONS. If there is any question about the surface of a bearing, wash it with cleaning solvent to remove oil. If the surface feels rough and abrasive, install a new bearing. Another indication of dirt in the bearing is excessive crankshaft wear.

Bent rods should be discarded. Do not attempt to align connecting rods by bending them.

Connecting Rod Bearing Installation

When replacing the bearings, see that the protruding tab on the back of each bearing half lines up with its corresponding recess in the connecting rod and bearing cap. This locks the bearing in place and keeps it from rotating.

For the torque to be used when tightening the nuts, see the topic, SPECIFICATIONS. It is permissible to exceed this value by the amount necessary to turn the nut to the next slot for alignment with the cotter pin hole.

Piston Pin Bearing

It is not always necessary to replace piston pin bearings at each engine reconditioning. They may last many thousands of hours if the oil has been kept clean.

After the oil has been cleaned from the pin and bearing, it is possible to feel the clearance between them. This normal oil clearance must not be mistaken for wear.

For permissible clearance see the topic, SPECIFICATIONS.

New connecting rods have the piston pin bearing bored in a special machine which maintains the proper center-to-center distance and parallelism of the connecting rod bearing and piston pin bore. Reconditioned rods should be machined in the same manner. See the topic, SPECIFICATIONS, for the correct center-to-center distance.

After pressing a new bearing in place, it should be machined accurately on a 2H6782 Rod Boring Machine. For the correct piston pin bearing bore size, see the topic, SPECIFICATIONS.

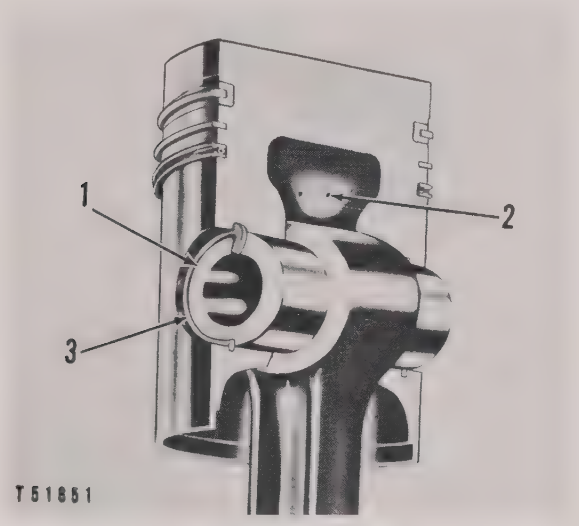
Pistons, Rings and Connecting Rods

(Natural Gas Engines)

PISTONS AND RINGS

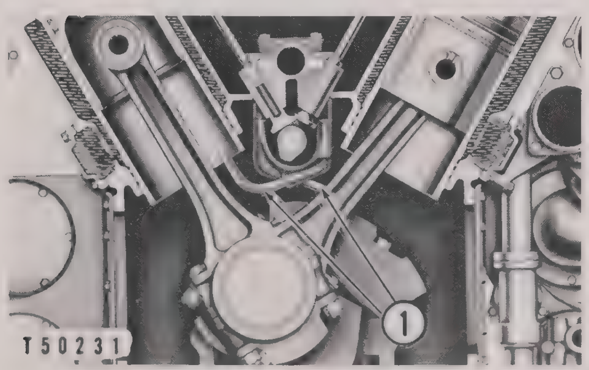
The aluminum alloy piston has three rings, consisting of two compression rings and one oil ring. All rings are located above the piston pin bore. The top compression ring seats in an integral cast iron band and the single oil ring is spring loaded. Holes **(2)** in the groove for the oil ring provide for the return of oil to the crankcase.

The full floating piston pin **(1)** is retained by two snap rings **(3)** which fit in grooves in the pin bore.



PISTONS AND RINGS
1–Piston pin. 2–Oil return hole. 3–Snap rings (two).

PISTON AND RING LUBRICATION



POSITION OF SPRAY TUBE
1–Spray tubes.

The pistons, the rings and the cylinder liners are lubricated by the oil that is thrown by the crankshaft while the engine is in operation.

Oil return holes in the piston oil ring groove provide for the return of oil to the crankcase.

The pistons are cooled and the piston pins are lubricated by spray tubes **(1)**, positioned in the cylinder block under each cylinder liner. A drilled passage connects the spray tubes directly to the oil manifold. Each spray tube assembly has two tubes which spray oil on pistons opposite each other in the block. Each tube assembly is held by two bolts, one on each side of the camshaft. They are accessible through the inspection openings in the side of the cylinder block.

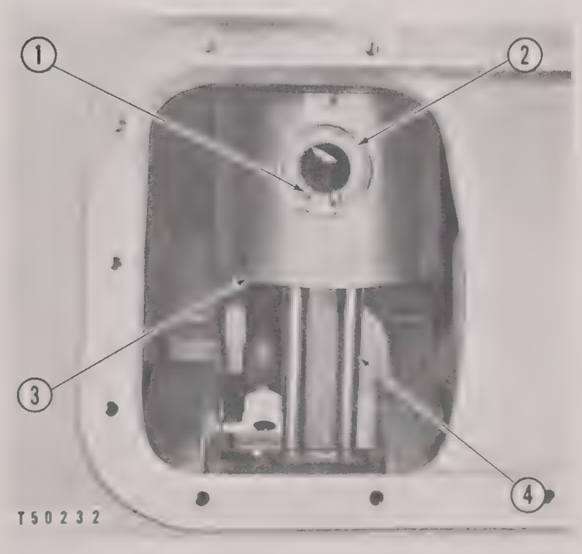
PISTONS

Removal and Installation

1. Move the compression release lever to the START position.
2. Remove the oil cooler and lines, oil pump, turbocharger lubrication valve and the water pump. See the covering topics.
3. Remove the bolts and lockwashers securing the inspection covers and remove the covers and gaskets.
4. Disconnect the connecting rod from the crankshaft. See the topic, CONNECTING ROD BEARING REMOVAL.
5. Move the piston and rod down until the piston pin and snap ring are visible but not so far as to allow the rings to slip out of the cylinder liner.

NOTE

The crankshaft must be rotated away from the connecting rod or both rods must be disconnected from the rod journal of the crankshaft to obtain enough clearance to move the rod and piston down.



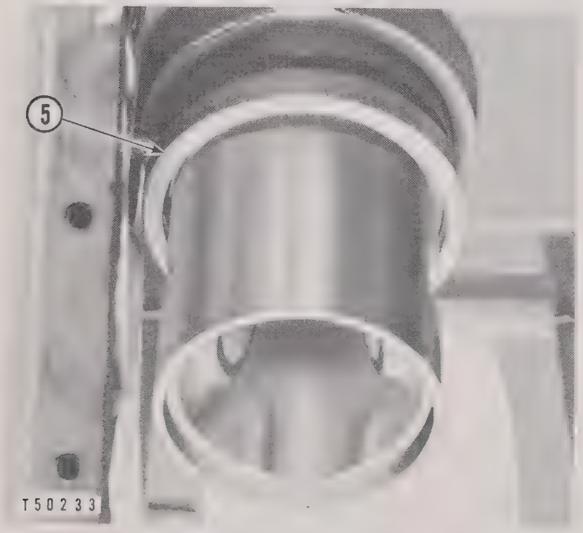
SNAP RING AND PISTON PIN REMOVAL
1–Snap ring. 2–Piston pin. 3–Piston. 4–Connecting rod.

6. Remove the snap ring **(1)** and piston pin **(2)** after rotating the piston **(3)** 90° in the cylinder liner. Support the connecting rod **(4)** so it will not fall.

NOTE

Inspect the snap ring for wear upon removal from the piston. If the snap ring fits snugly, it can be reused. If not, replace it upon installation.

7. Move the piston into the liner and remove the connecting rod.
8. Remove the piston from the cylinder. Clean and lubricate the cylinder wall, the piston and the piston rings with clean lubricating oil.
9. Using the piston ring compressor **(5)**, install the piston as shown. Keep the upper face of the ring compressor tight against the cylinder liner.



PISTON INSTALLATION
5–6H4140 Piston Ring Compressor.

10. Remove the ring compressor after the piston is inserted in the liner and install the remaining parts in the reverse order of removal.
11. Position the connecting rods and caps as indicated in the topic, CONNECTING RODS, and install.

NOTE

Upon installation of the connecting rod, align the V-mark on the piston skirt so that it faces outward from the bank of cylinders in which it is installed.

Cleaning and Inspecting Piston

Pistons which are not worn excessively or scored badly should be cleaned and used again. The ring grooves should be square and smooth. For permissible side clearance, see the topic, SPECIFICATIONS.

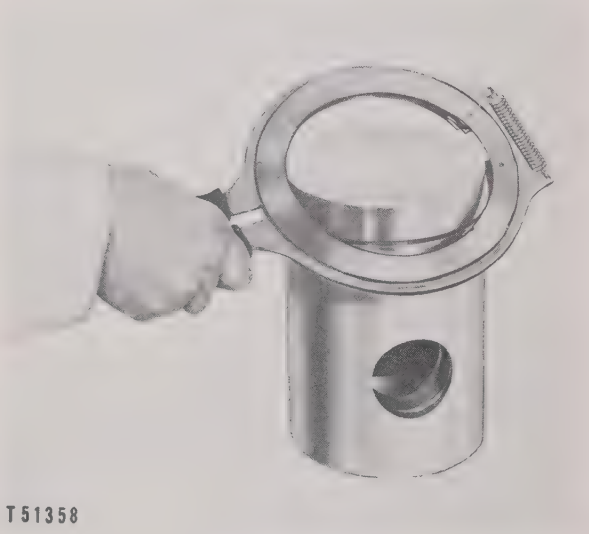
There are a number of good carbon solvents available for cleaning pistons. A carbon softener for use on engine pistons is fresh, cold water. Soak pistons in cold water overnight, let them dry (preferably in sunlight) and most of the carbon including that in the ring grooves can be easily rubbed off.

The use of broken rings or carbon scrapers on ring grooves should be avoided, as the grooves can be cut. A stick of hard wood does a good job and will not scratch the piston.

The bottom of each ring groove must be clean and the oil return holes in the oil ring groove must be open before the installation of new rings.

The area above the top ring can be filed smooth, but pistons badly scored below the top ring groove should be replaced.

RINGS



RING EXPANDER

Piston rings seal compression and control the amount of oil on the cylinder walls. If oil consumption is not excessive and compression is satisfactory, pistons should not be removed nor new rings installed when an engine is dismantled for some other reason.

To avoid damage to the piston, remove the rings with a 5H9621 Ring Expander.

The rings should be placed on the piston in the proper groove. Use the 5H9621 Piston Ring Expander when placing the rings in the grooves. The ring expander is not only a time saver but will also prevent breaking or distorting rings and damaging ring grooves.

For the ring gap of a new ring in a new liner, see the topic, SPECIFICATIONS.

CAUTION

The intermediate compression ring has the TOP marked. Be sure to install this ring correctly.

When new piston rings are to be used in worn cylinder liners, the ridge at the top of the liner should be raised as recommend in the topic, RECONDITIONING CYLINDER LINERS.

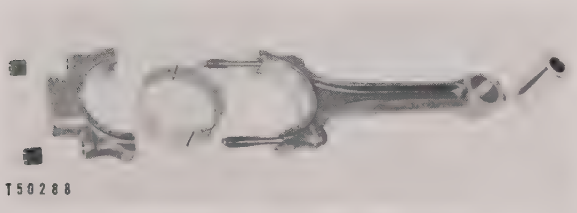
Whenever new rings, piston assemblies or piston and liner groups are installed, be sure to run-in the engine on a conditioning schedule before operating at normal load and speed. Do not run the engine idle for a long period after installing new rings or liners. Rings will not seat during idle operation. See the topic, RUNNING-IN SCHEDULE.

RUNNING-IN SCHEDULE

For the correct running-in procedures, follow the information that accompanies piston rings, piston assemblies and piston and liner groups sent from the Caterpillar Parts Department.

CONNECTING RODS

The bearing caps and rods are numbered consecutively, from the front of the engine on the outside so that the numbers can be seen through the inspection openings in the sides of the cylinder block. The rods must be reassembled with the numbers in this position, with the odd numbers visible on the right side of the engine, the even numbers on the left. For removal and installation of the connecting rods, see the topic, PISTONS.

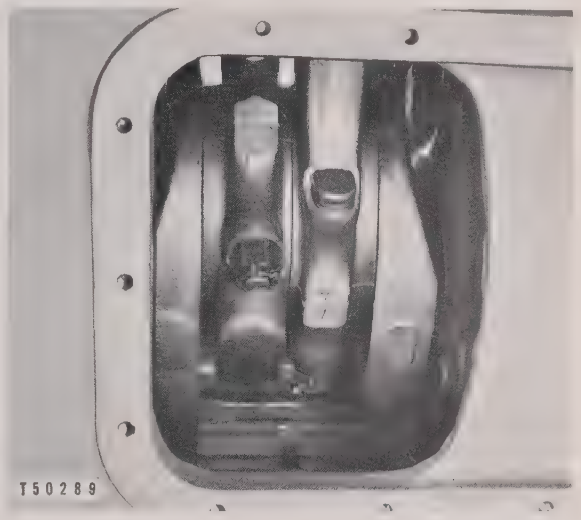

T50288

CONNECTING ROD AND PISTON PIN

Connecting Rod Bearing Removal

Connecting rod bearings are the precision type and are to be installed without fitting or scraping. The bearing halves can be removed, inspected and replaced through the inspection openings without removing the rod from the engine.

To remove a connecting rod bearing through the inspection opening, remove the cover and turn the crankshaft until the bearing to be removed is in the position shown in the illustration.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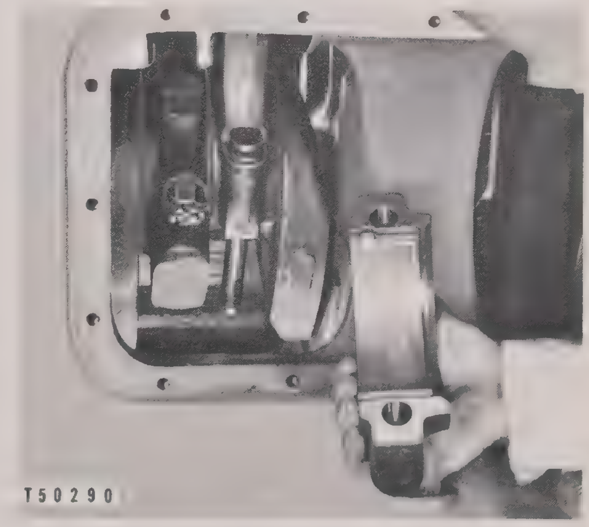
PREPARING TO REMOVE CONNECTING ROD CAP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REMOVING CONNECTING ROD BEARING CAP

Remove the cotter pins and the nuts from the connecting rod bolts with a 7F9303 Wrench and take out the cap and lower half of the bearing.

Rotate the crankshaft away from the rod or push the rod up slightly and remove the upper half of the connecting rod bearing.

Connecting Rod Bearing Inspection

Connecting rod bearings are steel-backed, aluminum-lined. Larger particles of dirt and abrasives in the oil do not tend to embed in aluminum bearings. Such particles roll around between the bearing and crankshaft journal causing scratches in the aluminum bearing without actually becoming embedded in the aluminum. Such scratches are not necessarily harmful and do not indicate that the bearings should be replaced.

For permissible bearing clearance, see the topic, SPECIFICATIONS. If there is any question about the surface of a bearing, wash it with cleaning solvent to remove oil. If the surface feels rough and abrasive, install a new bearing. Another indication of dirt in the bearing is excessive crankshaft wear.

Bent rods should be discarded. Do not attempt to align connecting rods by bending them.

Connecting Rod Bearing Installation

When replacing the bearings, see that the protruding tab on the back of each bearing half lines up with its corresponding recess in the connecting rod and bearing cap. This locks the bearing in place and keeps it from rotating.

For the torque to be used when tightening the nuts, see the topic, SPECIFICATIONS. It is permissible to exceed this value by the amount necessary to turn the nut to the next slot for alignment with the cotter pin hole.

Piston Pin Bearing

It is not always necessary to replace piston pin bearings at each engine reconditioning. They may last many thousands of hours if the oil has been kept clean.

After the oil has been cleaned from the pin and bearing, it is possible to feel the clearance between them. This normal oil clearance must not be mistaken for wear.

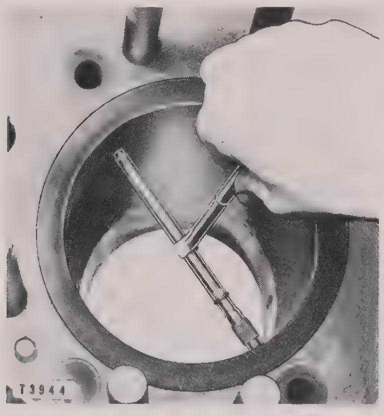
For permissible clearance see the topic, SPECIFICATIONS.

New connecting rods have the piston pin bearing bored in a special machine which maintains the proper center-to-center distance and parallelism of the connecting rod bearing and piston pin bore. Reconditioned rods should be machined in the same manner. See the topic, SPECIFICATIONS, for the correct center-to-center distance.

After pressing a new bearing in place, it should be machined accurately on a 2H6782 Rod Boring Machine. For the correct piston pin bearing bore size, see the topic, SPECIFICATIONS.

Cylinder Liners

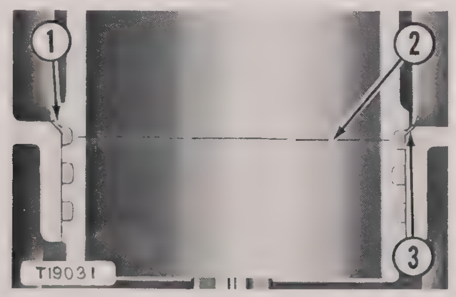
Cylinder liner surfaces are machined, hardened, ground, honed, and chemically treated to assure proper break-in. The resultant surface is so hard that ordinary boring tools will not machine it. Liners, pistons and rings are available from the factory in standard sizes only and require no fitting when they are installed.



CHECKING LINER WEAR

Cylinder liners should be replaced when they are worn at the top of the ring travel more than .020" or when they are scratched or scored.

Liner wear should be checked with inside micrometers, as shown.

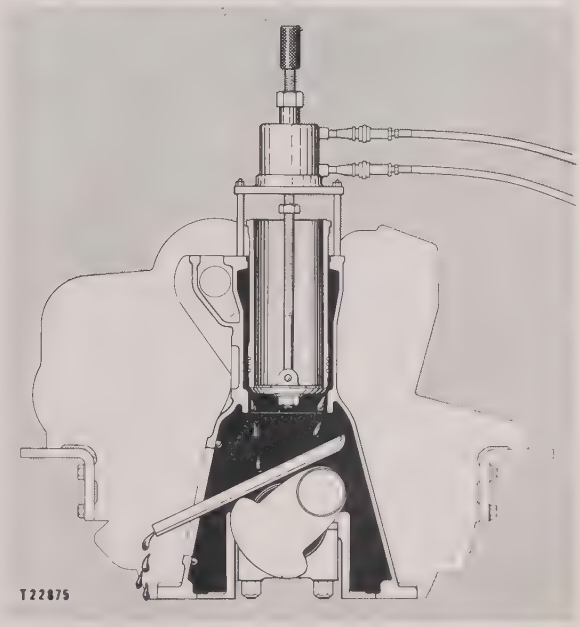


LINER SEALS
1–Top liner seal. 2–Center line of the top seal ring groove. 3–Cylinder bore chamfer.

Three O-ring seals fit in grooves on the lower end of each liner. The top seal **(1)** protects the cylinder bore chamfer **(3)** from rust and scale. The cylinder bore chamfer is machined to permit the lower edge of the chamfer to align with the center line **(2)** of the top seal ring groove as illustrated.

REMOVING AND INSTALLING CYLINDER LINERS

1. Drain the cooling system.
2. Remove the cylinder heads, the connecting rods and the pistons as outlined in their respective topics.
3. Place a piece of cardboard or heavy gasket material through the inspection openings as illustrated, to protect the inside of the engine.
4. Install the 7F1857 Puller, the 6H4141 Adapter Plate and the 7F9540 Hydraulic Puller.
5. Remove the cylinder liner and clean the water jacket sediment from the cylinder block.
6. When installing the cylinder liner, always use new rubber seals. Coat the rubber seals with liquid soap to ease installation.



PULLING CYLINDER LINER WITH HYDRAULIC PULLER

7. Lower the cylinder liner carefully into the block. The liners can be driven into place by using a suitable driver, or by placing the puller adapter on the top of the liner. A block of hard wood, to be used as a driving block, is then placed on the puller adapter.
8. Drive the liner into the cylinder block until it bottoms. Then hit the block of wood several light taps, to assure that the liner is in. If the last blow bottoms the liner too hard, the liner may bounce back out a trifle.

NOTE

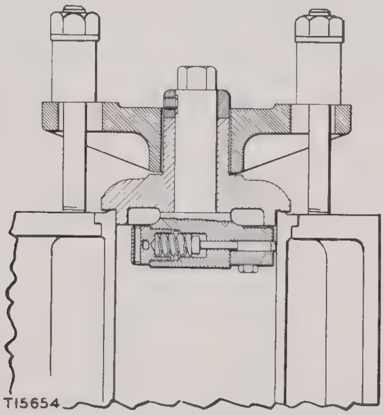
Properly installed liners should extend slightly above the face of the cylinder block. This insures proper holding and sealing of the cylinder liner against the cylinder head gasket when the cylinder head is drawn down. Some liners may feel slightly loose in the cylinder block, yet serve satisfactorily without water or antifreeze leaking past the rubber seals.

9. Remove the cardboard and assemble the parts in the reverse order of removal.

RECONDITIONING CYLINDER LINERS

Removing Ridge from Worn Cylinder Liners

When new piston rings are to be used in worn cylinder liners, the ridge in the liner at the top of the ring travel should be raised to provide clearance for the new top ring. Since the liners are too hard for ordinary tools, a liner ridge boring tool should be used. The illustration shows how the tool is installed. Information regarding the tool illustrated is available upon request.



LINER RIDGE BORING TOOL

The tungsten carbide tool bit is spring-loaded and specially ground so it will follow the worn contour of the liner and will not cut deeper than the worn surface. Instructions for its use accompany the tool.

CAUTION

Be careful not to rotate the tool counterclockwise when the tool bit is against the liner wall. Doing so will break the cutting edge.

If the engine does not break in properly, see the topic, RUNNING-IN SCHEDULE.

14A-10-360

THIS GROUP OUT OF STOCK, PLEASE RE-ORDER UPON
RECEIVING THIS MANUAL

Crankshaft

The crankshaft is supported by steel-backed, aluminum-lined main bearings. The end thrust is taken by two steel-backed, aluminum-lined, crescent-shaped bearings installed in the rear main bearing cap. The front main bearing cap is machined for thrust bearings, also. This enables the thrust to be taken at the front for certain applications.

The crankshaft has identical flanged ends and gears cut integrally at each end, both being the same size. This allows the same crankshaft to be used for both clockwise and counterclockwise rotation. Holes are drilled in the center of each crankpin to lighten the shaft. The holes are then plugged to provide a reservoir for oil from the main bearings to the connecting rod bearings. Counterweights are bolted to the crankshaft and drilled for balance.

The crankshaft should be replaced or reground if the wear or out-of-roundness exceeds the maximum value given in the topic, SPECIFICATIONS. If the crankshaft is reground, it should be reground .050" undersize, as replacement bearings are available in this size.

REMOVAL AND INSTALLATION

1. Turn the engine on its side as outlined in the topic, REMOVING AND INSTALLING MAIN BEARINGS.
2. Remove the connecting rod bolts and caps. Push the pistons and connecting rods into the cylinders far enough to clear the crankshaft.

NOTE

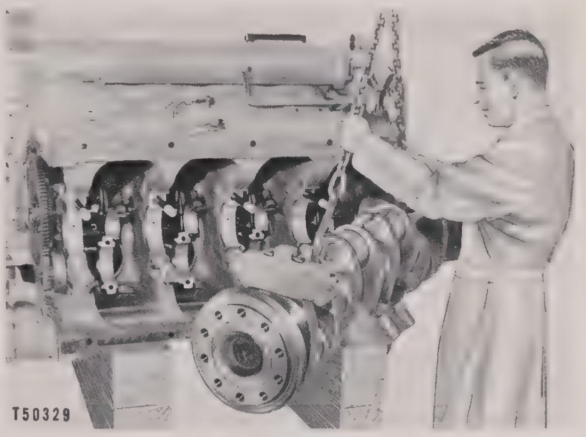
The piston rod caps are numbered. Be sure to keep the proper bearings with the cap unless new bearings are to be installed.

3. Install two ½" - 13 (NC) eyebolts into the tapped holes in the cheek of No. 2 and No. 4 main bearing journals and attach a suitable hoist.

NOTE

On the D398, the tapped holes are located in the cheek of No. 2 and No. 6 main bearing journal.

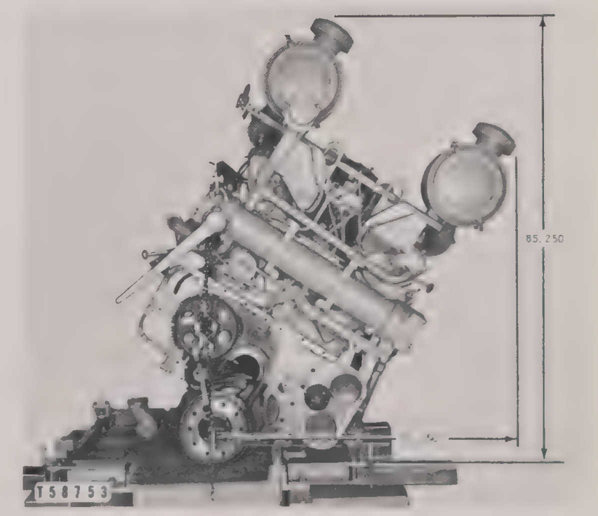
4. Tighten the cable just enough to prevent the crankshaft from moving when the main bearing caps are removed. Remove the main bearing caps.
5. Wrap the threads of the lower studs as illustrated to prevent damage to the crankshaft bearing surface when the crankshaft is being removed.
6. Remove the crankshaft as illustrated.



REMOVING THE CRANKSHAFT
(D379 Illustrated)

7. Install the crankshaft in the reverse order of removal. See the topic, TIMING GEARS AND TIMING MARKS, for proper timing of the crankshaft gear. Lubricate the bearings and check the clearances. If the bearing clearance exceeds the maximum value given in the topic, SPECIFICATIONS, replace the bearings. See the topic, SPECIFICATIONS, for the proper torque of the bearing cap stud nuts.

TILTING METHOD OF REMOVING AND INSTALLING ENGINE CRANKSHAFT



ENGINE TILTED
(Sufficient Clearance)

WARNING

Never use the engine tilting group unless the engine base is securely fastened to its foundation.

The procedure described is for removing the crankshaft where there is a minimum of overhead and side clearance (less than 85¼″ from the base to the top of the air cleaner and less than 63¼″ side clearance from the centerline of the engine). If sufficient clearance is available, it will not be necessary to remove any parts from the top of the engine.

Tools for Tilting Engine

In addition to the 8F2550 Engine Tilting Group, the tools illustrated are required to tilt the engine.

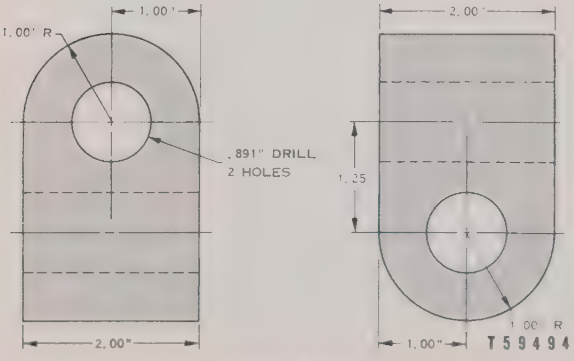
PART NO.	* COL. 1	** COL. 2	DESCRIPTION
—	4	4	BRACKET – MILD STEEL
—	6	6	SUPPORT – MILD STEEL
—	2	2	BEAM
8F4239	8	4	BLOCK – MILD STEEL
—	2	2	STUD – 1.25" DIA. 10" LONG
—	2	2	STUD – 1.25" DIA. 20.50" LONG
5B1181	4	0	TURNBUCKLE – 1.25"
8F4230	4	0	STUD – 1.25" DIA. 14.5" LONG
8F4231	4	0	STUD – 1.25" DIA. 9" LONG
8F4226	8	0	YOKE
5F9892	20	44	PIN
S-1587	12	12	CAPSCREW – 1/2"– 13– 1 3/4" BRACKET TO CYLINDER HEAD
1B4334	8	0	NUT – 1 1/4"– 7
1D4609	12	12	BOLT – 3/4"– 10– 3" SUPPORT TO OIL PAN
1B4331	12	12	NUT – 3/4"– 10
1A8628	6	6	CAPSCREW – 1/2"– 13– 5" THRU SUPPORT
1D4719	6	6	NUT – 1/2"– 13
8F4225	4	0	CAPSCREW – 3/4"– 10– 10" GUIDE PIN
8F4233	4	0	BLOCK – HINGE
8F4228	4	0	YOKE
L-1178	4	0	CAPSCREW – 3/4"– 10– 2" YOKE TO OIL PAN
1A5964	12	12	BOLT – 3/8"– 16– 4 1/2" – BEAM TO SUPPORT
1D4717	12	12	NUT – 3/8"– 16
3B4618	40	8	COTTER PIN – 1/8"– 1 1/4"

*COL. 1 – TOTAL NO. REQ'D. FOR THIS GROUP.
**COL. 2 – NO. REQ'D. IN ADDITION TO THE NO. REQ'D. FOR THE 8F2550 ENGINE TILTING GROUP. T59493

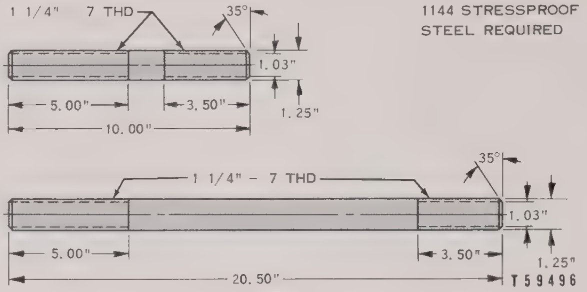
TOOLS REQUIRED TO TILT ENGINE

NOTE

Apply ⅜″ fillet weld all around on all lugs.

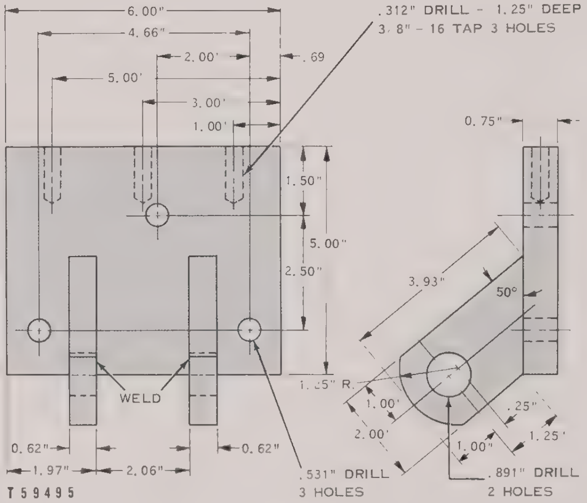

1.00"
1.00" R
.891" DRILL
2 HOLES
2.00"
2.00"
1.25
1.00 R
1.00"
T59494

8F4239 BLOCK

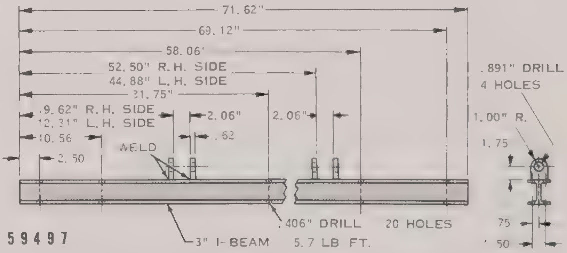

1 1/4" 7 THD
35°
1.03"
1.25"
5.00"
3.50"
10.00"
1 1/4" - 7 THD
35°
1.03"
5.00"
3.50"
1.25"
20.50"
T59496

1144 STRESSPROOF STEEL REQUIRED

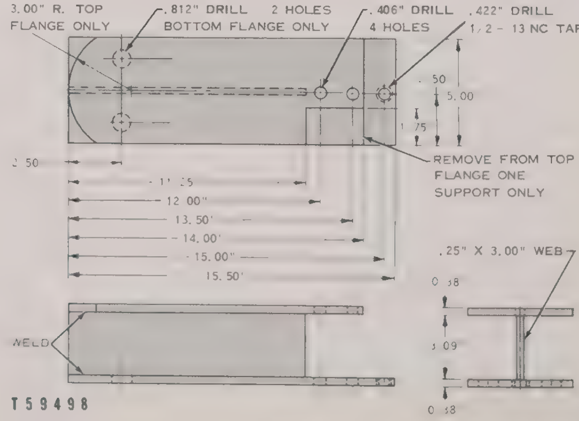
STUDS


6.00"
4.66"
2.00"
.69
5.00"
3.00"
1.00"
.312" DRILL - 1.25" DEEP
3/8" - 16 TAP 3 HOLES
0.75"
1.50"
5.00"
2.50"
3.93"
50°
1.25" R.
1.00"
.25"
2.00"
1.25"
1.00"
WELD
0.62"
1.97"
2.06"
0.62"
.531" DRILL
3 HOLES
.891" DRILL
2 HOLES
T59495

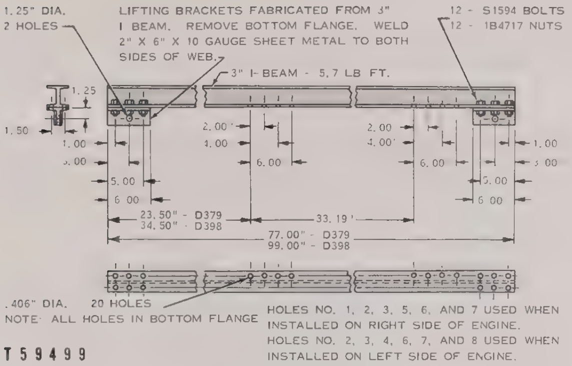
BRACKET


71.62"
69.12"
58.06"
52.50" R.H. SIDE
44.88" L.H. SIDE
31.75"
9.62" R.H. SIDE
12.31" L.H. SIDE
2.06"
2.06"
.62
10.56
2.50
WELD
.891" DRILL
4 HOLES
1.00" R.
1.75
.406" DRILL 20 HOLES
3" I-BEAM 5.7 LB FT.
75
50
T59497

LEFT AND RIGHT SIDE SUPPORT BEAMS


3.00" R. TOP
FLANGE ONLY
.812" DRILL 2 HOLES
BOTTOM FLANGE ONLY
.406" DRILL
4 HOLES
.422" DRILL
1/2 - 13 NC TAP
.50
5.00
1.75
2.50
12.00"
13.50"
14.00"
15.00"
15.50"
REMOVE FROM TOP
FLANGE ONE
SUPPORT ONLY
.25" X 3.00" WEB
WELD
T59498

SUPPORT

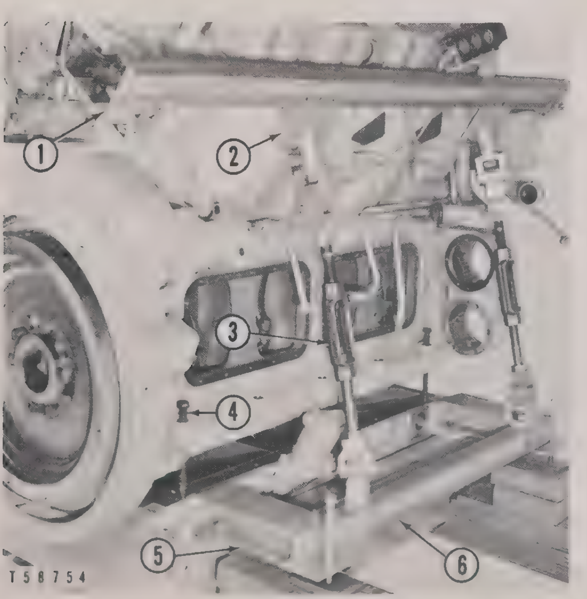

1.25" DIA.
2 HOLES
LIFTING BRACKETS FABRICATED FROM 3" I BEAM. REMOVE BOTTOM FLANGE. WELD 2" X 6" X 10 GAUGE SHEET METAL TO BOTH SIDES OF WEB.
12 - S1594 BOLTS
12 - 1B4717 NUTS
3" I-BEAM - 5.7 LB FT.
1.25
1.50
1.00
3.00
5.00
6.00
2.00
4.00
6.00
2.00
4.00
6.00
1.00
3.00
5.00
6.00
23.50" - D379
34.50" - D398
33.19
77.00" - D379
99.00" - D398
.406" DIA. 20 HOLES
NOTE: ALL HOLES IN BOTTOM FLANGE
HOLES NO. 1, 2, 3, 5, 6, AND 7 USED WHEN INSTALLED ON RIGHT SIDE OF ENGINE.
HOLES NO. 2, 3, 4, 6, 7, AND 8 USED WHEN INSTALLED ON LEFT SIDE OF ENGINE.
T59499

LIFTING BEAM

Tilting Engine and Removing Crankshaft

All tools referred to are illustrated in the topic, TOOLS FOR TILTING ENGINE.

1. Remove the air cleaner, governor controls, inlet manifolds, turbocharger and aftercooler, and the water line which connects the regulator housings. See the covering topics.
2. Remove the fuel filter assembly, water pump, oil cooler and starting mechanism. See the covering topics.
3. Remove the fuel transfer pump and engine oil pump as an assembly. See the covering topic.
4. Remove the bolts which secure the engine to the oil pan and install four 8F4225 Bolts **(4)** in the oil pan as illustrated.


1
2
3
4
5
6
T58754

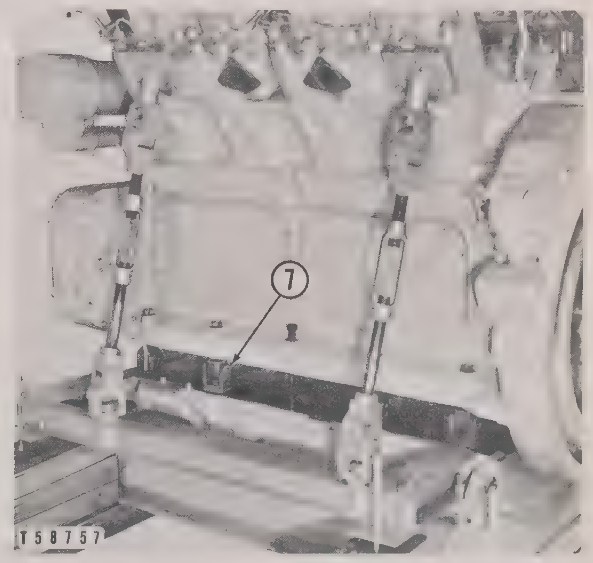
ENGINE RAISED
1–Lifting beam. 2–Bracket. 3–5B1181 Turnbuckle. 4–8F4225 Bolt. 5–Support. 6–Right support beam.

5. Install the beam **(6)** and supports **(5)** on both sides of the engine as illustrated. Place blocks under the supports and beam for added support.

NOTE

The beams **(6)** are not interchangeable from one side of the engine to the other.

6. Secure the brackets **(2)** to the cylinder heads and bolt the beam **(1)** in place.
7. Connect the turnbuckles **(3)** to the bracket **(2)** and the beam **(6)** using 8F4230 Studs on the lower end and 8F4231 Studs on the upper end of the turnbuckles **(3)**.
8. Use the turnbuckles **(3)** to raise the engine high enough to install the hinge assemblies **(7)** under the left side of the engine as illustrated.



HINGES INSTALLED
7–Hinge assembly (four).

NOTE

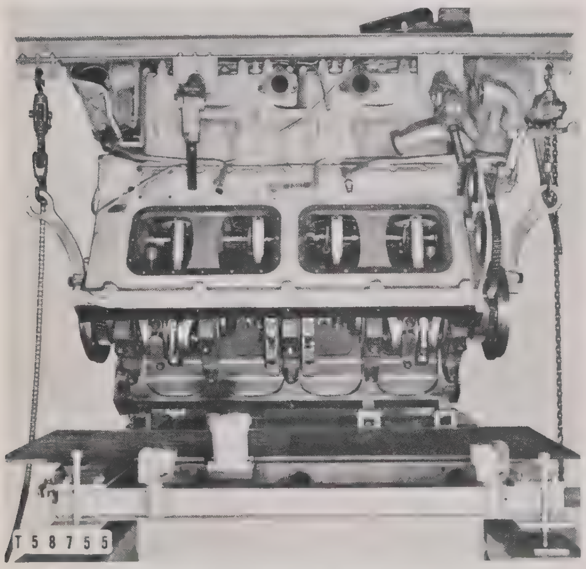
When raising the engine, keep all the turnbuckles as even as possible.

9. Remove the guide bolts (4) after the hinge assemblies have been installed.
10. Remove the timing gear cover, the flywheel housing and flywheel. See the covering topics.
11. Disconnect the turnbuckles on the hinged side of the engine and raise the other side of the engine until the studs are even with the inside base of the turnbuckle opening.

CAUTION

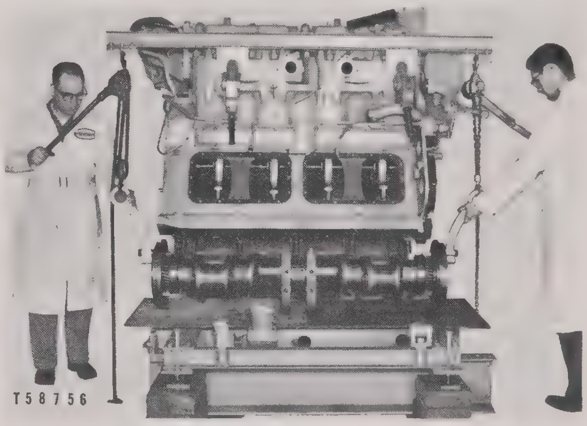
Extending the studs any farther might cause damage to the threads on the studs and in the turnbuckles and result in accidentally dropping the engine.

12. Block under the raised side of the engine and install the 20.5″ studs in place of the 8F4230 Studs on the lower ends between the turnbuckles and the blocks.
13. Continue tilting the engine until the studs have been extended their permissible distance.
14. Connect the turnbuckles on the hinged side of the engine using the 10″ studs in place of the 8F4230 Studs. Take up on the 10″ studs and turnbuckles until all slack is eliminated.
15. Disconnect the turnbuckles on the raised side of the engine and close the turnbuckles on the hinged side of the engine.
16. Place a clean covering over the oil pan as illustrated to prevent foreign particles from entering and to provide a platform to receive the crankshaft when it is lowered.
17. Install an 8F4423 Lifting Bracket on each end of the crankshaft and attach suitable hoists between the ends of the lifting beam **(1)** and the 8F4423 Lifting Brackets as illustrated.



PREPARING TO REMOVE MAIN AND ROD BEARING CAPS

18. Open the compression release on both cylinder heads.
19. Remove the connecting rod bearing caps and bearings and push the pistons and rods to the top of their stroke.
20. Tie the pistons and rods on the raised side of the engine so they will not drop down.
21. Remove the main bearing caps and bearings and remove the crankshaft as illustrated.

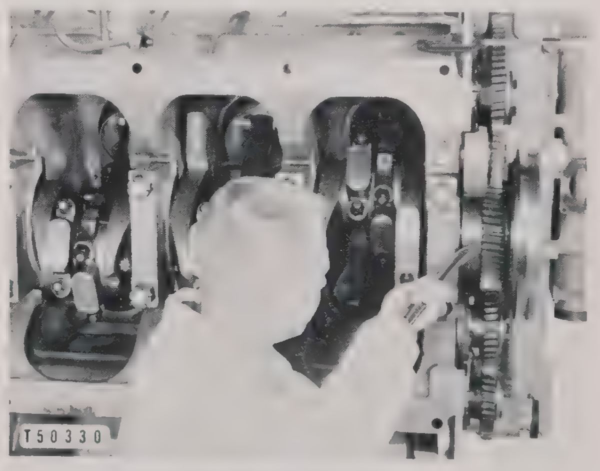


REMOVING THE CRANKSHAFT

22. Install the crankshaft in the reverse order of removal. Align all timing marks and tighten the main and rod bearing bolts to the torque value listed in the topic, SPECIFICATIONS.
23. Reverse the tilting procedure and return the engine to its upright position. Install new gaskets as needed.

CRANKSHAFT END THRUST

The crankshaft end thrust is taken by two steel-backed, aluminum-lined, crescent-shaped bearings installed in the machined grooves of the rear main bearing cap. The front main bearing cap is also machined for thrust bearings.



CHECKING CRANKSHAFT END CLEARANCE

End clearance can be checked by mounting a dial indicator against the flange at one end of the crankshaft. Push the crankshaft as far forward one end as possible and read the indicator. Push the crankshaft as far to the other end as possible and read the indicator. The difference between the readings will be equal to the end clearance.

See the topic, SPECIFICATIONS, for the proper end clearance.

CRANKSHAFT OIL THROWER

Both the front and the rear of the engine are sealed with throwers pressed on the flanges of the crankshaft. Each thrower has a spring-loaded, piston ring-type seal. The throwers confine the crankcase oil in its compartment while the rings provide an additional oil seal as well as exclude dirt.

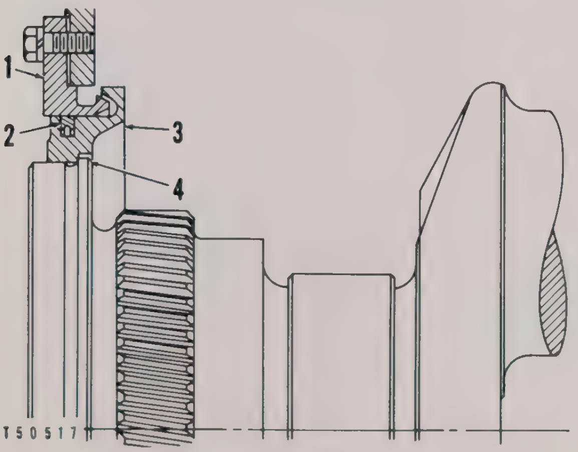
Removal and Installation

Throwers should be removed if worn, damaged or improperly installed. On the D379, the throwers have to be removed to remove or install the balancer gears. Always inspect the ring-type seals and check the runout on the ring groove of the throwers when either the accessory drive housing or flywheel housing is removed.

Throwers will, in most cases, be damaged during the removal procedure if a puller is used. Burn or cut off to expedite removal and install a **new** thrower.

CAUTION

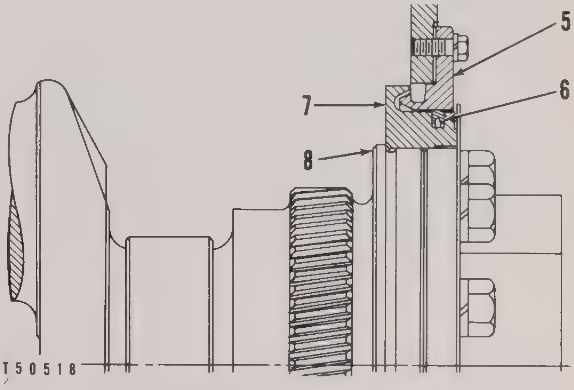
Be especially careful not to damage the ring seal grooves. Ring seals will bind in damaged grooves and rotate with the crankshaft which eventually will cause oil leakage.



REAR THROWER PROPERLY INSTALLED
1-Baffle. 2-Ring seal. 3-Thrower. 4-Shoulder of flange.

Heat the throwers (preferable in oil) and start them on the crankshaft. Use an 8B7548 Puller, a 7F9540 Hydraulic Puller, two 8B7556 Adapters and an FT105 Push Plate to complete the installation of the throwers and insure they are installed flush against the crankshaft shoulders. See the illustrated tool set up in the Service Tool Manual.

Runout on ring groove face and bottom, which accommodates ring seal, must not exceed .006" total indicator movement when installed on crankshaft.



FRONT THROWER PROPERLY INSTALLED
5-Baffle. 6-Ring seal. 7-Thrower. 8-Shoulder of flange.

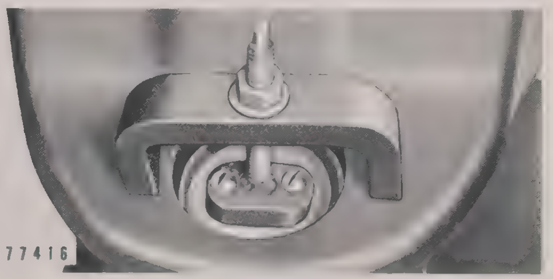
NOTE

The word OUT is stamped on the ring seals **(2)** and **(6)** for proper installation. The word OUT should face away from the engine. Lubricate the ring seal and groove prior to seal installation. The seal must turn freely in the groove after assembly. The leading edges of the baffles **(1)** and **(5)** are chamfered to facilitate installation over the ring-type seals.

CRANKSHAFT PLUGS

The plugs located in the throws of the crankshaft should be removed and the accumulations of sludge, carbon deposits, varnish, etc. removed from the cavities. Clean the drilled passages leading from the main bearing journals to the cavities.

Removal



CRANKSHAFT PLUG REMOVAL

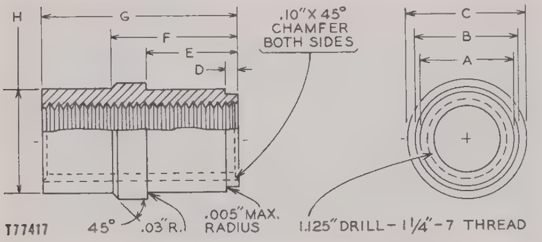
Remove the crankshaft plug retaining ring.

Use a puller arrangement (similar to the one shown) to remove the plug from the crankshaft.

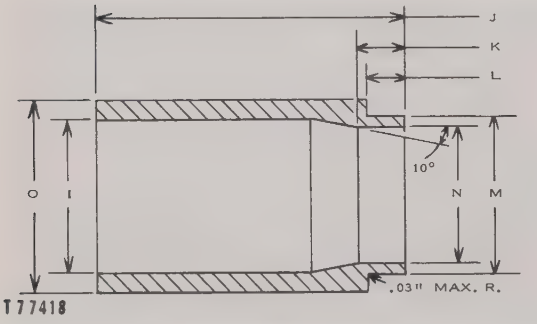
Installation

NOTE

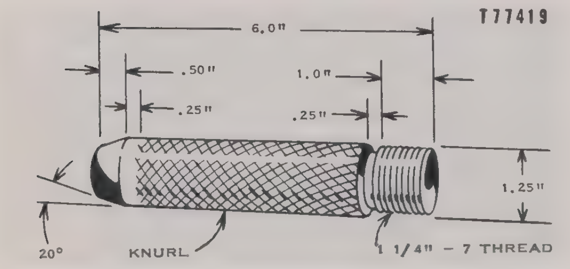
The installation tools consist of a sleeve, driver and handle.


H
G
F
E
D
.10"X 45° CHAMFER BOTH SIDES
C
B
A
T77417
45°
.03"R.
.005" MAX. RADIUS
1.125" DRILL - 1 1/4"-7 THREAD

DRIVER DIMENSIONS
A–2.110". B–2.234". C–2.400". D–.19". E–1.00".
F–2.00". G–3.50". H–2.234".


J
K
L
10°
O
I
N
M
.03" MAX. R.
T77418

SLEEVE DIMENSIONS
I–2.404". J–3.50". K–.62". L–.47". M–2.370".
N–2.248". O–3.00".

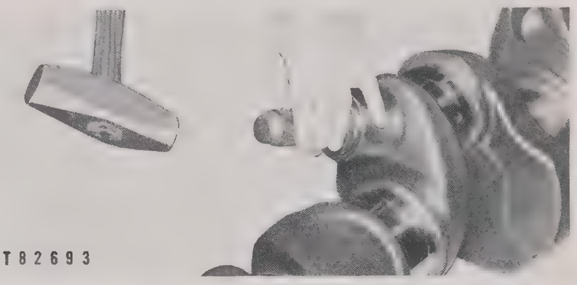

T77419
6.0"
.50"
1.0"
.25"
.25"
1.25"
20°
KNURL
1 1/4" - 7 THREAD

HANDLE DIMENSIONS

CAUTION

Make certain the groove for the retaining ring is unobstructed.

1. Assemble the handle into the driver so the plug driving end is ready for use.
2. Place a new plug on end of the driver and drive the plug into the crankshaft. Drive the plug in far enough to allow installation of the retaining ring.
3. Position the sleeve in the hollow of the crankpin and slip the retaining ring into the sleeve.
4. Remove the handle from the driver and install in the opposite end of the driver.
5. Drive the retaining ring through the sleeve and into the crankshaft.



CRANKSHAFT PLUG RETAINING RING INSTALLATION

CAUTION

Make certain the crankshaft plug retaining ring is seated around the entire periphery of the groove.

Balancer

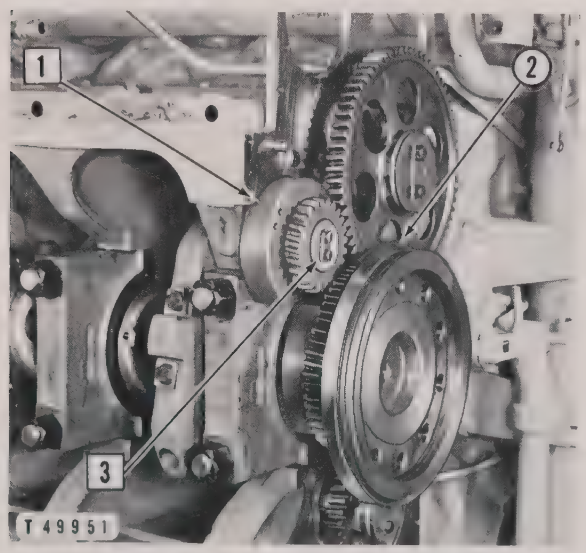
(D379 Only)

A gear-type balancer is provided on this engine to counteract vertical inertia forces of the connecting rods and pistons. The balancer counteracts these forces by means of weights (balance gears) rotating at twice engine speed. If these rotating weights are properly installed, they cancel the unbalanced forces; but if not properly installed, they may actually add to the connecting rod and piston intertia forces, thus increasing engine vibration.

One rotating balancer is located at the right front of the engine and the other is located at the left rear. The front balancer is driven by an idler gear which in turn is driven by the crankshaft gear. The rear balancer gear is driven by the camshaft gear cluster which is driven by the crankshaft gear.

REMOVAL AND INSTALLATION

1. Remove the front accessory drive housing as described in the topic, FRONT ACCESSORY DRIVE.
2. Remove the oil pan and flywheel housing as described in the covering topics.
3. Support the engine on its left side.

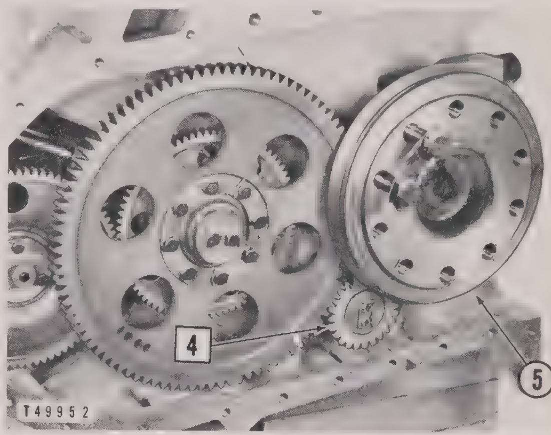


FRONT BALANCER GEAR REMOVAL

☐ **Remove**

1–Balancer gear. 2–Thrower. 3–Retainer.

4. Position the balancer as illustrated.
5. Remove the throwers **(2)** and **(5)** as described in the topic, CRANKSHAFT.



REAR BALANCER GEAR REMOVAL

☐ **Remove**

4–Balancer gear. 5–Thrower.

6. The balancer gear shafts are pressed into the block and can be removed and replaced if necessary.
7. Before installing a new balancer gear shaft, chill the shaft cool enough to allow .002″ to .003″ shrinkage.
8. Using a soft hammer, drive the shaft into the block. The distance between the face of the block and the end of the balancer shaft is 2.684″ - 2.688″.
9. If it is necessary to replace the balancer gear bearing, align the new bearing so that the seam is toward the center of the weighted side of the gear.
10. Install the front balancer gear referring to the topic, FRONT ACCESSORY DRIVE for the correct timing procedure.

NOTE

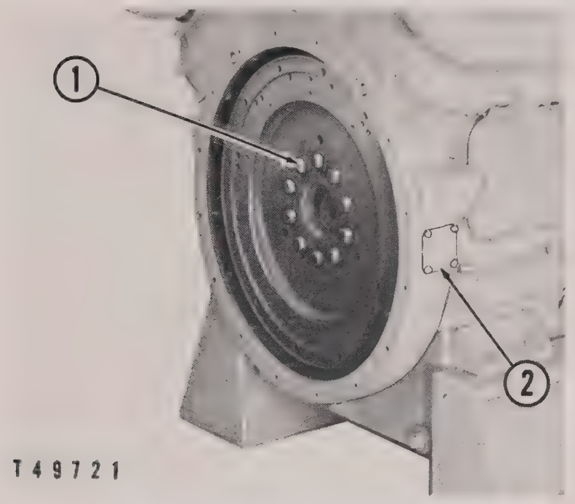
See the topic, SPECIFICATIONS, for the correct bearing clearance and retainer bolt torque.

11. Install the rear balancer gear referring to the topic, TIMING GEARS, for the correct timing procedure.

Flywheel and Flywheel Housing

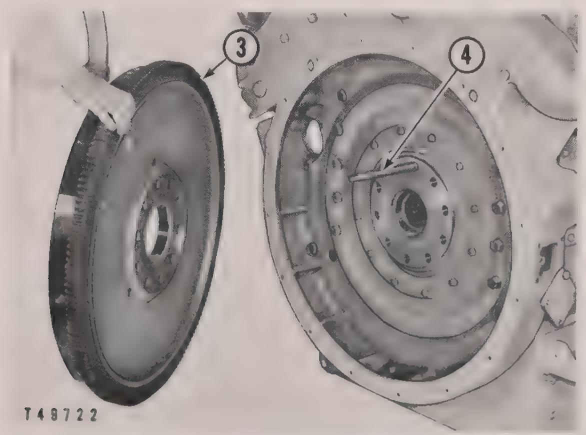
FLYWHEEL AND RING GEAR

Removal and Installation



PREPARING TO REMOVE THE FLYWHEEL
1–Bolts. 2–Cover.

1. Remove the pointer under the cover **(2)**.
2. Remove the bolt in the highest position in the circle of bolts **(1)** and install a 7/8" - 14 (NF) guide pin **(4)**.
3. Attach a suitable hoist to the flywheel and remove the remaining bolts **(1)** and locks.
4. Remove the flywheel and ring gear **(3)** from the housing as illustrated.



REMOVING FLYWHEEL
3–Ring gear. 4–Guide pin.

5. Press, cut or burn the ring gear from the flywheel, if replacement is necessary.
6. Before installing a ring gear, clean both the ring gear and the flywheel and remove all burrs that might interfere with seating the ring gear flush to the flywheel shoulder.
7. Heat the ring gear (not to exceed 600°F) and install it so the chamfered portion of the ring gear teeth face toward the starter pinion when the flywheel is installed.

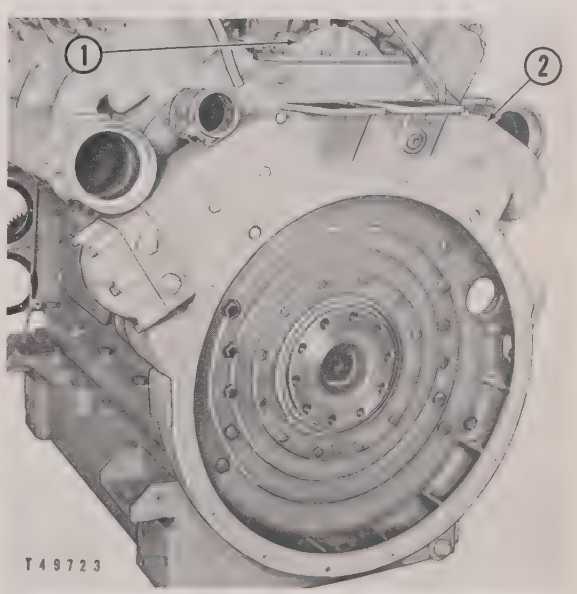
NOTE

The chamfer on the ring gear teeth must face the cylinder block on both electric and air started models. It must face toward the rear on models equipped with a gasoline starting engine.

8. Align the marks on the flywheel and the crankshaft flange and install the flywheel over the guide pin onto the crankshaft.
9. Remove the guide pin and install the locks and bolts. Tighten the flywheel bolts evenly and diametrically to the torque value given in the topic SPECIFICATIONS.

FLYWHEEL HOUSING

Removal and Installation

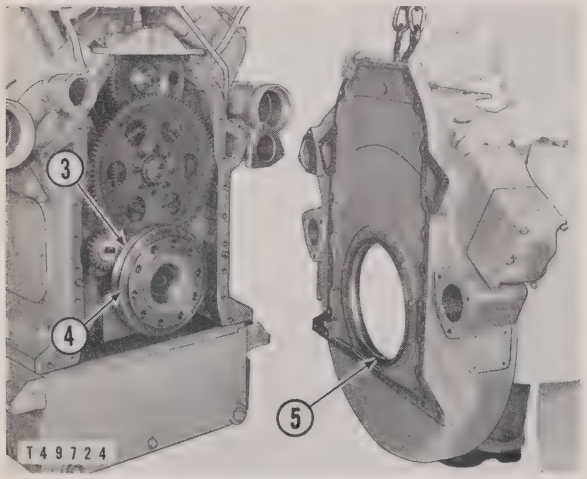


PREPARING TO REMOVE THE FLYWHEEL HOUSING
1–Cover. 2–Flywheel housing.

1. Remove the aftercooler as described in the covering topic.
2. Remove the flywheel as previously described.
3. Back off all the bolts securing the engine block

to the oil pan base and remove the bolt securing the oil pump assembly to the oil pan. Raise the rear of the engine approximately 3/8″ and put spacers between the engine block and oil pan base.

4. Install two eyebolts through the aftercooler support on the flywheel housing and attach to a suitable hoist.
5. Remove the bolts securing the flywheel housing **(2)** to the engine block and to the fuel pump and governor drive housing gear cover **(1)**.
6. Loosen the remaining bolts in the fuel pump and governor drive housing gear cover **(1)**.
7. Remove the flywheel housing as illustrated.



REMOVING FLYWHEEL HOUSING
3–Thrower. 4–Ring seal. 5–Baffle.

CAUTION

Move the flywheel housing away from the dowel pins evenly on each side by prying between the flywheel housing and the crankcase near the dowel pins to avoid damaging the thrower **(3)**.

8. Inspect the baffle **(5)** and replace it if worn or damaged. Nicks and burrs should be removed from the chamfered edge to prevent damage to the piston ring seal during installation.
9. Inspect the gasket and replace those sections that are damaged.
10. Install the flywheel housing.

NOTE

The leading edge of the baffle **(5)** is chamfered so that the piston ring seal **(4)** will compress in its groove and center in the baffle bore.

11. Remove the spacers from between the oil pan base and engine block and tighten the bolts. Replace the bolts in the oil pan assembly.

Service Manual
Section Index Tab
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ISSUED 4-64

STARTING ENGINE

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STARTING ENGINE

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STARTING ENGINE

SPECIFICATIONS

Bore and stroke	3⅝ x 4
High idle	2900 RPM
Low idle	1100 RPM

Camshaft

Journal diameter, front	2.1205 - 2.1215 in.
Journal diameter, rear	1.3725 - 1.3735 in.
Bearing clearance, front	.0025 - .0045 in.
Bearing clearance, rear	.0015 - .0035 in.
Permissible bearing clearance	.006 in.
End clearance	.003 - .011 in.
Permissible end clearance	.015 in.

Camshaft Idler Gear (Later)

Bearing journal diameter	1.2495 - 1.2525 in.
Bearing clearance	.001 - .005 in.

Connecting Rod

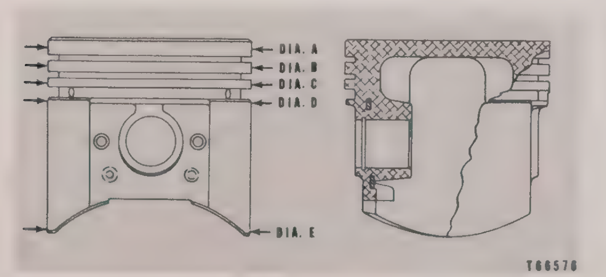
Connecting rod bearing clearance (Earlier)	.0021 - .0052 in.
Connecting rod bearing clearance (Later)	.0032 - .0058 in.
Permissible bearing clearance	.009 in.
Bolt nut torque	36 lb. ft.
Center-to-center distance (Earlier)	8.499 - 8.501 in.
Center-to-center distance (Later)	6.999 - 7.001 in.
Bore in piston pin bearing [new rod assem. std. (Earlier)]	1.0943 - 1.0946 in.
Bore in piston pin bearing [for .007″ oversize pins (Earlier)]	1.1013 - 1.1016 in.
Bore in piston pin bearing [new rod assem. std. (Later)]	.8597 - .8601 in.

Crankshaft

Main journal diameter	2.1240 - 2.1250 in.
Permissible main journal wear	.007 in.
Main bearing clearance (Earlier)	.0060 - .0097 in.
Main bearing clearance (Later)	.0055 - .0095 in.
Permissible bearing clearance (Earlier)	.016 in.
Permissible bearing clearance (Later)	.012 in.
End clearance, front main bearing	.005 - .010 in.
Permissible end clearance	.025 in.
Main bearing bolt torque	60 - 70 lb. ft.
Connecting rod journal diameter	1.998 - 1.999 in.
Permissible rod journal wear	.004 in.
Permissible out-of-round	.003 in.

Cylinder Bore

Diameter	3.628 - 3.629 in.
Cylinder bore wear limit (out-of-round)	.003 in.
Cylinder bore wear limit (taper)	.005 in.



OVERSIZE PISTON DIMENSION
(Tapered skirt piston illustrated)
A, B, and C–Land diameters. D–Diameter at top of piston skirt. E–Diameter at bottom of piston skirt.

CYLINDER BORE AND PISTON DIMENSIONS
(For tapered skirt pistons)

Measurement	STANDARD (New)	.020″ Oversize	.040″ Oversize
Cylinder Diameter	3.628″-3.629″	3.648″-3.649″	3.668″-3.669″
Piston Land Diameter (A)	3.600″-3.604″	3.620″-3.624″	3.640″-3.644″
Piston Land Diameter (B)	3.608″-3.612″	3.628″-3.632″	3.648″-3.652″
Piston Land Diameter (C)	3.608″-3.612″	3.628″-3.632″	3.648″-3.652″
Skirt Taper	Diameter at (D) to be .0010″-.0015″ less than diameter at (E).		

CYLINDER BORE AND PISTON DIMENSIONS
[For straight skirt pistons (Earlier)]

Measurement	.020″ Oversize	.040″ Oversize	.060″ Oversize
Cylinder Diameter	3.648″-3.649″	3.668″-3.669″	3.688″-3.689″
Piston Land Diameter	3.618″-3.619″	3.638″-3.639″	3.658″-3.659″
Piston Skirt Diameter	3.640″-3.641″	3.660″-3.661″	3.680″-3.681″

Cylinder Head

Bolt torque (Earlier)	50 - 60 lb. ft.
Bolt torque (Later)	64 - 70 lb. ft.

Magneto

Cover screw torque	1.7 lb. ft.
Contact point gap	.015 in.
Ignition timing (Before top center)	25°
Impulse kick-out speed	275 - 350 RPM
Impulse lag angle	11° - 14°

Oil Pump

Clearance between gears and end covers (total)	.001 - .003 in.
Shaft diameter	.4934 - .4940 in.
Bearing bore	.4962 - .4968 in.
Bearing clearance	.0022 - .0034 in.
Permissible bearing clearance	.006 in.
Pressure relief spring (Earlier):	
Free length	1.250 in.
Pounds force	7.43 - 8.72
When compressed to	.825 in.
Pressure relief spring (Later):	
Free length	1.250 in.
Pounds force	6.6 - 7.7
When compressed to	.875 in.
Oil pressure, minimum PSI at high idle	25

Pinion Mechanism

Clearance, pinion to spacer	.010 - .030 in.
Plunger spring:	
Pounds force	24
When compressed to	1.156 in.
Pinion return spring:	
Pounds force	15
When compressed to	7.625 in.

Pistons

Bore in piston	1.0939 - 1.0943 in.
Skirt clearance of new piston	.006 - .008 in.
Bore in piston (for .007" oversize pin)	1.1016 - 1.1021 in.

Piston Pins

Clearance in rod bearing:	
Earlier	.0008 - .0013 in.
Later	.0005 - .0011 in.
Permissible clearance between bearing and pin:	
Earlier	.003 in.
Later	.0025 in.
Clearance in piston	.0005 - .0010 in.
Permissible clearance between piston and pin	.0025 in.

Piston Rings

Compression ring gap (measured in standard cylinder bore)	.009 - .023 in.
Oil ring gap (measured in standard cylinder bore)	.009 - .022 in.
Compression ring groove clearance	.0020 - .0036 in.
Oil ring groove clearance	.0010 - .0025 in.
Permissible groove clearance (new ring) compression and oil rings	.009 in.

Spark Plug

Gap (Later)	.030 in.
Torque	30 lb. ft.

Starting Motor (12V — Delco-Remy 1108171)

Brush spring tension (minimum)	24 oz.
Rotation (viewing drive end)	Counterclockwise
No load test:	
Volts	11.3
Maximum Amps	70
Approximate RPM	6000
Lock test:	
Volts	6.7
Maximum Amps	530
Minimum torque	16 lb. ft.

Valves (Inlet and Exhaust)

Clearance:	
Hot	.008 in.
Cold	.009 in.
Stem clearance in guide	.002 - .004 in.
Permissible valve clearance with new valve	.007 in.
Valve face angle	44¼°
Valve seat angle	45°

Valve Lifters

Lifter diameter	.6845 - .6850 in.
Bore diameter	.6865 - .6875 in.
Clearance	.0015 - .0030 in.
Permissible clearance	.0075 in.

Valve Spring

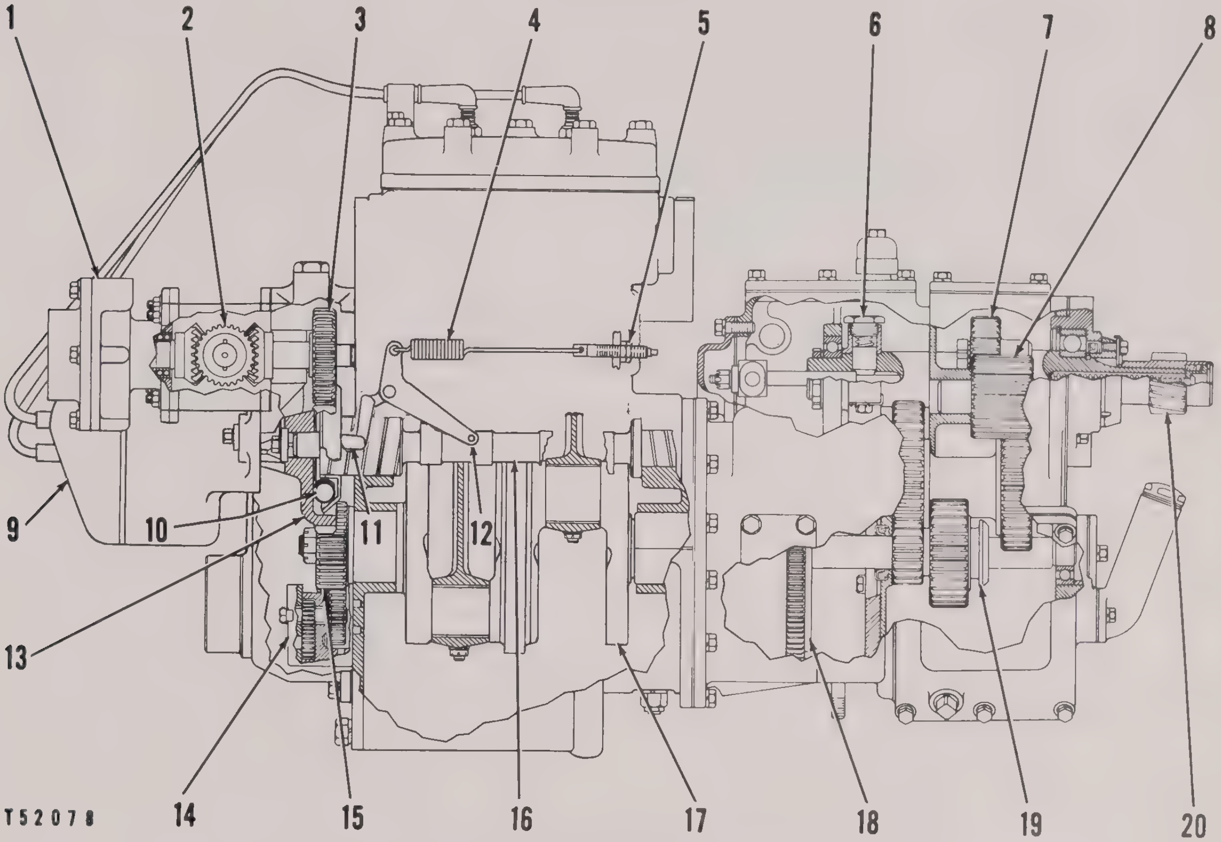
Free length	1.969 in.
Pounds force	32.5 - 37.5
When compressed to	1.594 in.

Valve Timing

With valve clearances set .009" cold, dial indicator mounted above valve head, reading taken with valve .075" off its seat:

Earlier:	
Exhaust opening (before bottom center)	14° 44′
Exhaust closing (before top center)	12° 33′
Inlet opening (after top center)	11° 16′
Inlet closing (after bottom center)	13° 27′
Later:	
Exhaust opening (before bottom center)	27° 21′
Exhaust closing (before top center)	12° 10′
Inlet opening (after top center)	10° 39′
Inlet closing (after bottom center)	25° 50′

Operation



STARTING ENGINE NOMENCLATURE

1–Water pump.
2–Handcrank mechanism bevel gear.
3–Water pump and hand-crank drive gear.
4–Governor spring.
5–Governor speed adjusting nuts.
6–Pinion latch mechanism.
7–Pinion shaft gear.
8–Idler gear.
9–Magneto.
10–Governor.
11–Governor control fork.
12–Governor control lever.
13–Camshaft gear.
14–Oil pump.
15–Crankshaft gear.
16–Camshaft.
17–Crankshaft.
18–Flywheel.
19–Transmission sliding gear.
20–Starter pinion.

The starting engine is mounted on the left side of the diesel engine cylinder block. The engine is a two-cylinder, four-cycle, gasoline-operated type.

The starting engine cooling system is combined with the cooling system of the diesel engine. The water pump (1) circulates the coolant through the starting engine and the diesel engine. This cools the starting engine and shortens the warm-up time for the diesel engine. See the topic, COOLING SYSTEM, for the flow diagram and description of the combined cooling system.

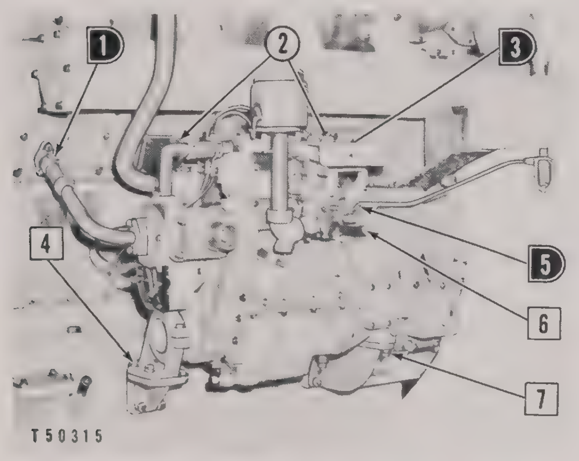
Removal and Installation

1. Shut off the fuel supply at the fuel tank.

NOTE

If the starting engine is equipped with an electric starter, disconnect the battery cables first at the battery and then at the starting engine.

2. Drain the coolant from the diesel engine. Drain the coolant from the starting engine block at **(6)**.

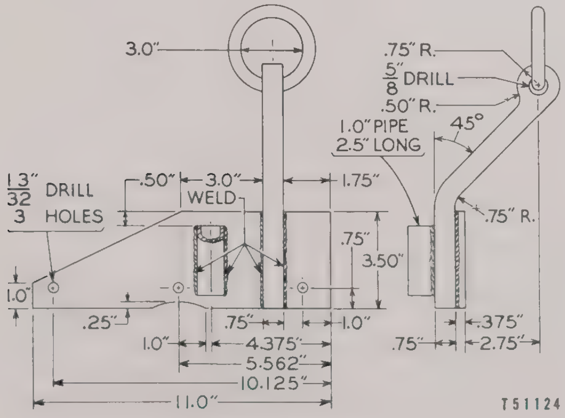

1
2
3
4
5
6
7
T50315

PREPARING TO REMOVE THE STARTING ENGINE

☐ **Remove** ◗ **Disconnect**

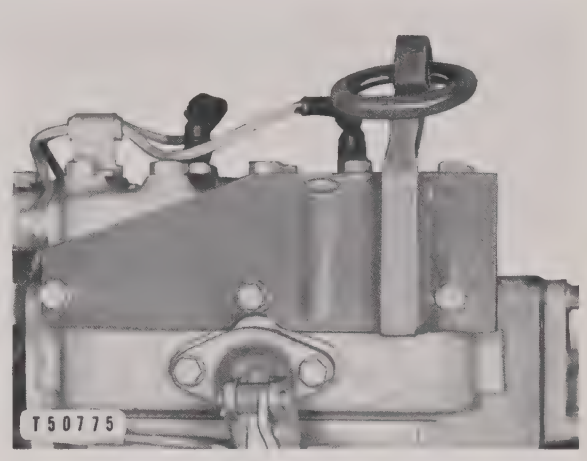
1–Coolant inlet line. 2–Upper brackets. 3–Coolant outlet line. 4–Bolts (four). 5–Fuel line. 6–Coolant drain. 7–Bolts (two).

3. Remove the air cleaner pipe and switch bracket.


3.0"
.75" R.
5/8" DRILL
.50" R.
1.0" PIPE 2.5" LONG
45°
13/32" DRILL 3 HOLES
.50"
3.0"
WELD
1.75"
.75" R.
.75"
3.50"
1.0"
.25"
.75"
1.0"
1.0"
4.375"
5.562"
10.125"
11.0"
.375"
.75"
2.75"
T51124

LIFTING BRACKET

4. Attach the lifting bracket, illustrated, to the starting engine block, and attach a suitable hoist with a capacity of at least 500 lbs.



ATTACHING LIFTING BRACKET

5. Engage the starting engine pinion with the diesel engine flywheel.

6. Remove the bolts which secure the starting engine to the upper support brackets **(2)**.

CAUTION

Make sure there is no slack in the hoist chain, since the hoist will support the starting engine when these bolts are removed.

7. Move the starting engine forward until the pinion is clear of the flywheel housing.

REMOVING STARTING ENGINE
2–Upper brackets. 3–Coolant outlet line.

8. Install in reverse order of removal.

CAUTION

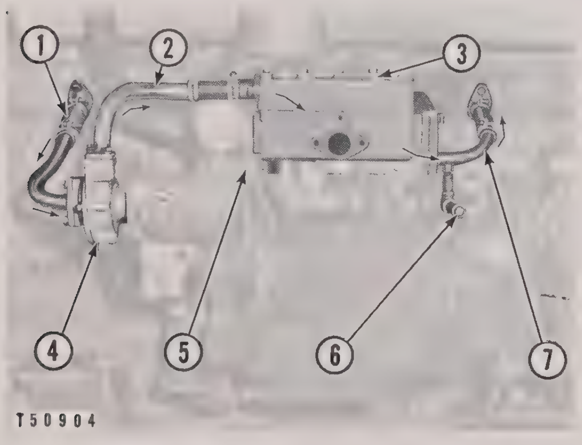
Check the starting engine crankcase oil level before starting the engine

Cooling System

FLOW OF COOLANT

The starting engine cooling system makes use of the diesel engine coolant and cooling system.

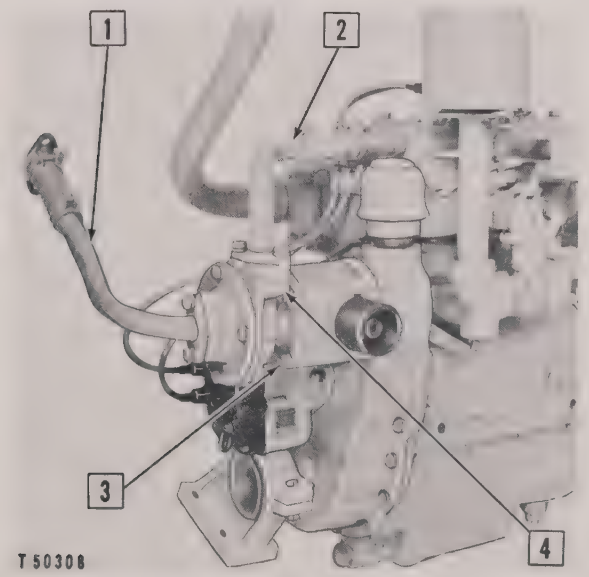
The starting engine water pump **(4)** draws coolant from the diesel engine block through line **(1)**. From the water pump, the coolant flows through line **(2)** to the starting engine cylinder head **(3)** and block **(5)** cooling the engine. The coolant flows back to the diesel engine through line **(7)**. When the starting engine is to be removed, drain the block at the drain **(6)**.



STARTING ENGINE COOLANT FLOW
1–Inlet water line. 2–Water pressure line. 3–Cylinder head. 4–Water pump. 5–Cylinder block. 6–Block drain. 7–Outlet water line.

WATER PUMP

Removal and Installation



PREPARING TO REMOVE WATER PUMP

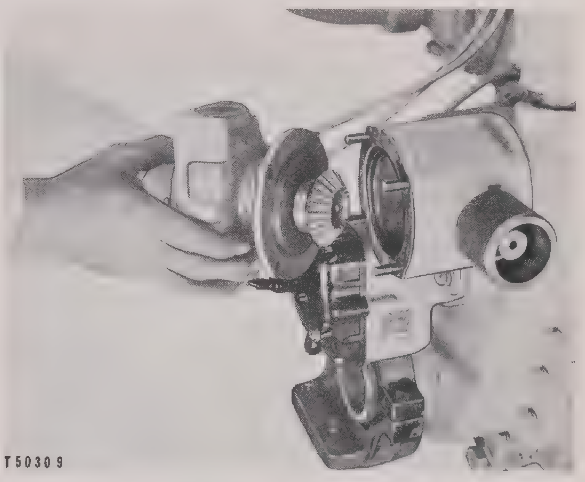
☐ Remove

1–Inlet water line. 2–Water pressure line. 3–Nuts. 4–Water pump.

The starting engine water pump group can be removed without removing the starting engine from the diesel engine.

Drain the coolant from the diesel engine and starting engine.

Install in the reverse order of removal, replacing all worn or damaged gaskets.



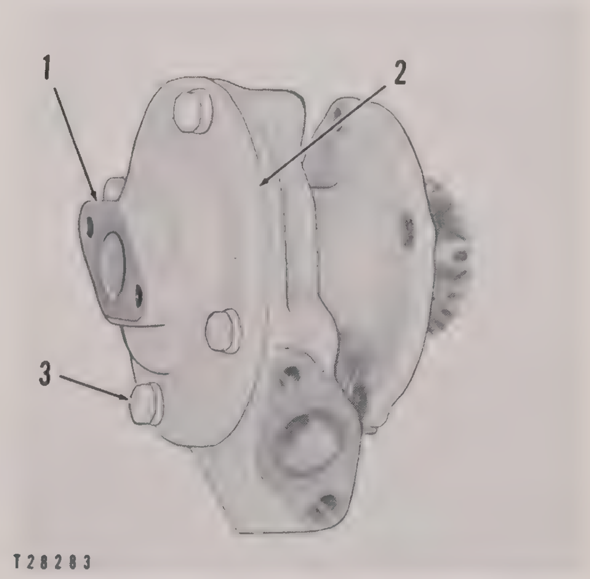
REMOVING WATER PUMP

Disassembly and Assembly

1. Remove the bolts **(3)** which secure the cover **(2)** to the pump housing **(8)** and remove the cover.

NOTE

When assembling the water pump, install the cover so that the flange **(1)** will be in a vertical

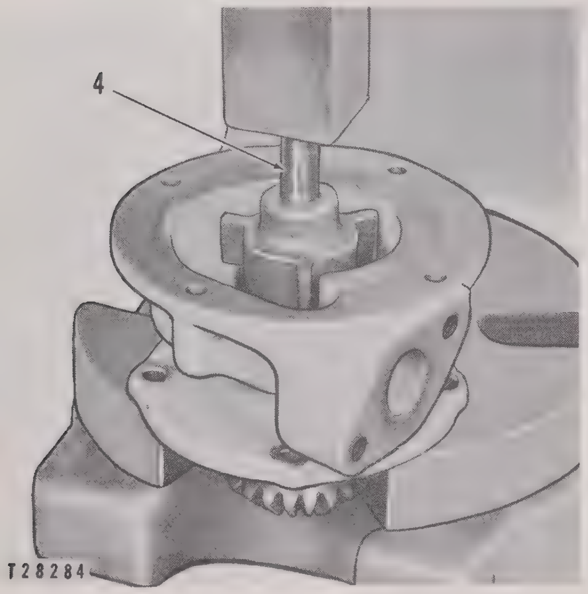


WATER PUMP DISASSEMBLY
1–Flange. 2–Cover. 3–Bolt.

position when the pump is mounted on the starting engine.

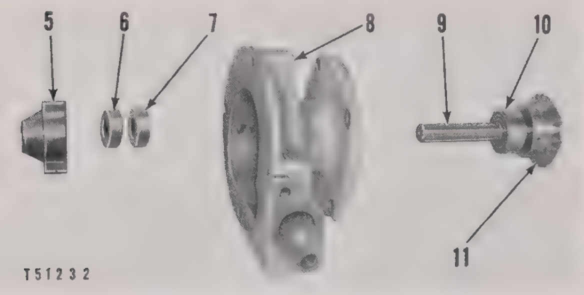
2. With the aid of a suitable hand press and a spacer **(4)**, press the shaft **(9)**, bearing **(10)**, and water pump drive gear **(11)** from the impeller **(5)** as illustrated.

3. Remove the spring pin **(13)** which positions the gear on the shaft.



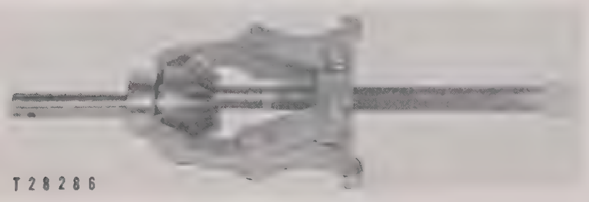
REMOVING SHAFT
4–Spacer.

4. Using an 8H695 Puller and a suitable spacer, pull the gear from the shaft, as illustrated.



EXPLODED VIEW OF WATER PUMP
5–Impeller. 6–Seal. 7–Seal. 8–Housing. 9–Shaft. 10–Bearing. 11–Gear.

5. Remove the key **(12)** from the shaft.



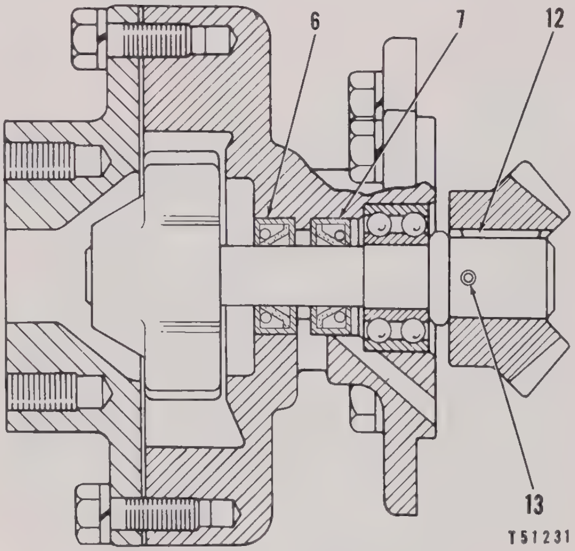
PULLING GEAR

6. Press the bearing **(10)** from the shaft.

7. Press the seals **(6)** and **(7)** from the water pump housing.

NOTE

The lip of the seal **(7)** should be toward the drive gear and the lip of seal **(6)** toward the impeller when installed in the pump housing.



WATER PUMP CROSS-SECTION
6–Seal. 7–Seal. 12–Key. 13–Spring pin.

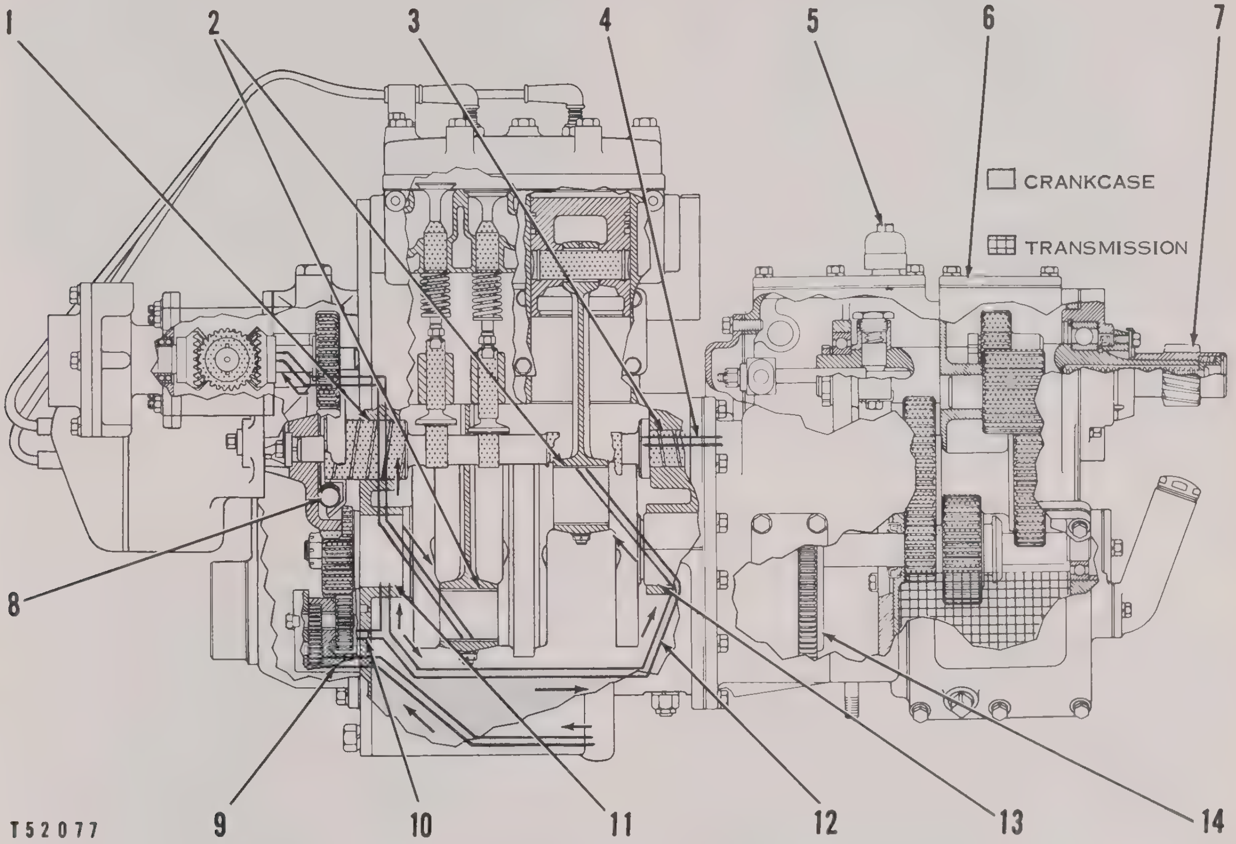
8. Assemble in the reverse order of disassembly, replacing all worn or damaged gaskets.

NOTE

After installing the spring pin **(13)**, peen both ends of the hole.

Lubrication System

FLOW OF LUBRICATING OIL



FLOW OF LUBRICATING OIL

1–Camshaft front bearing bore.
2–Connecting rod bearings.
3–Camshaft rear bearing bore.
4–Oil return trough.
5–Transmission breather.
6–Transmission housing.
7–Starter pinion.
8–Governor.
9–Oil pump inlet line.
10–Oil pump outlet line.
11–Crankshaft front bearing.
12–Oil tube.
13–Crankshaft rear bearing.
14–Flywheel.

OIL PAN

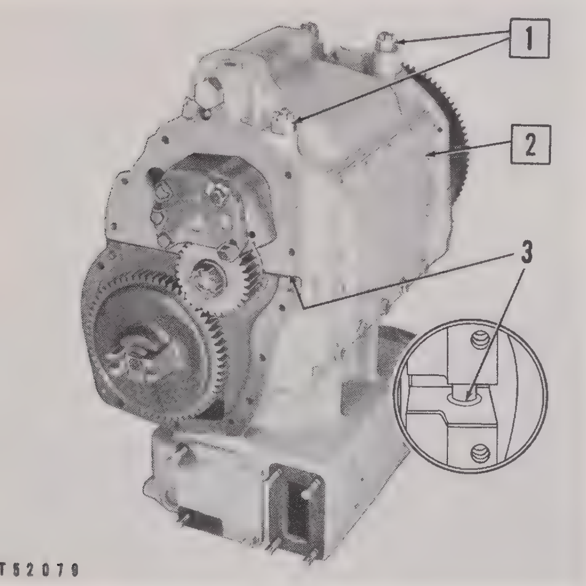
Oil Pan Removal and Installation

To remove the oil pan from the cylinder block, it is first necessary to remove the clutch and transmission housing and the timing gear housing. See the topics, CLUTCH AND TRANSMISSION HOUSING REMOVAL and TIMING GEAR HOUSING REMOVAL. With these parts removed, place the engine in a position so that it is supported on its head.

NOTE

A spacer washer (3) is located on each of the oil pan studs between the pan and cylinder block. The pan gasket has holes large enough to pass over these washers to form a good seal. The spacer washers are used to prevent crushing the main bearing and must be in place before installing the oil pan on the cylinder block. Be sure the holes in the gasket are centrally located around the spacer washers to prevent shearing away part of the gasket, which would result in oil leakage around the pan studs.

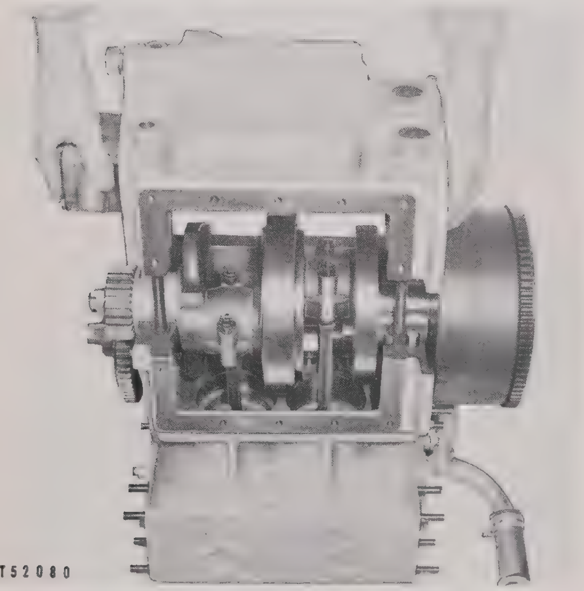
Over



OIL PAN REMOVAL

☐ Remove

1–Nuts (four). 2–Inspection cover. 3–Spacer washer.

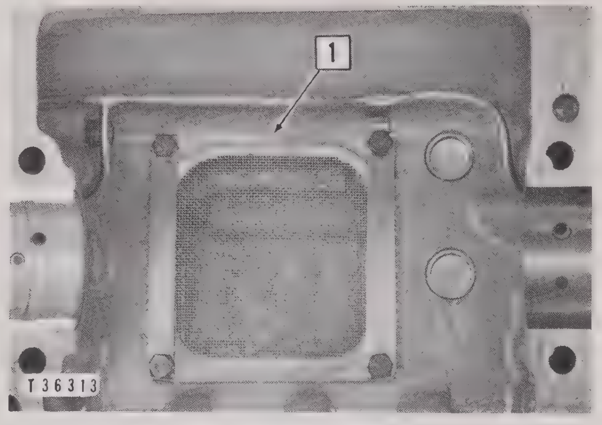


LIFTING THE OIL PAN FROM THE BLOCK

See the topic, SPECIFICATIONS, for the correct oil pan nut torque.

Sump Screen Removal and Installation

Clean the pan and make sure all passages are open.



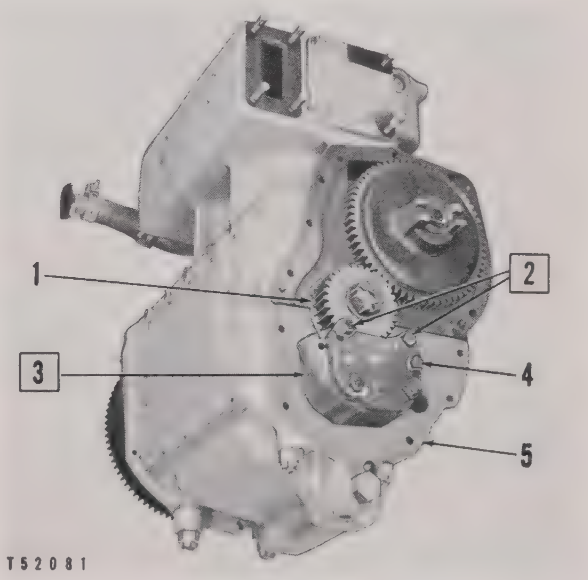
SUMP SCREEN REMOVAL

☐ Remove

1–Screen.

OIL PUMP

Oil Pump Removal and Installation



PREPARING TO REMOVE OIL PUMP

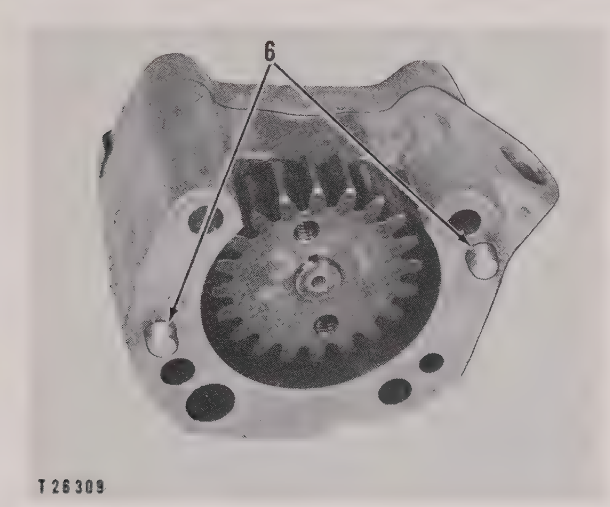
☐ Remove

1–Crankshaft gear. 2–Bolts (four). 3–Oil pump. 4–Bolt. 5–Oil pan.

The oil pump **(3)** is mounted on the front of the oil pan **(5)** and inside the timing gear housing. It is driven directly from the crankshaft gear **(1)**, and has two dowels **(6)** and four bolts to secure it to the pan.

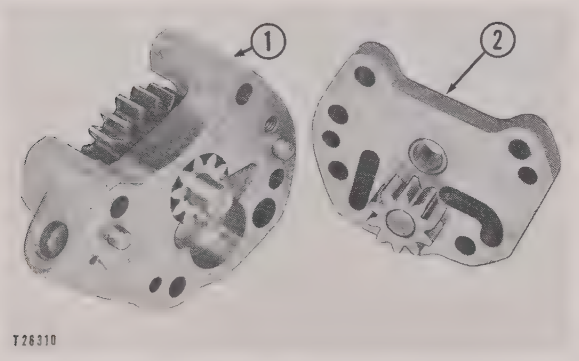
Remove the bolts **(2)** and remove the oil pump from the engine pan. The bolt **(4)** is to be removed only when the pump is to be disassembled.

Clean the mating surfaces before installation.

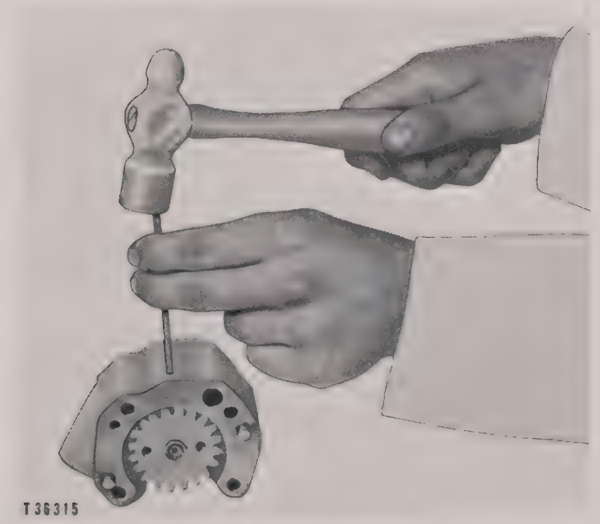


OIL PUMP REMOVED
6–Dowels.

Oil Pump Disassembly and Assembly



PUMP COVER REMOVAL
1–Pump body. 2–Cover.



REMOVAL OF DRIVE SHAFT AND GEAR PIN

1. Remove the bolts which hold the cover **(2)** to the pump body **(1)**.
2. Separate the cover from the body.
3. Drive the tapered pin from the pump drive shaft and gear as shown.
4. Inspect all gears, bearings and shaft before assembly.

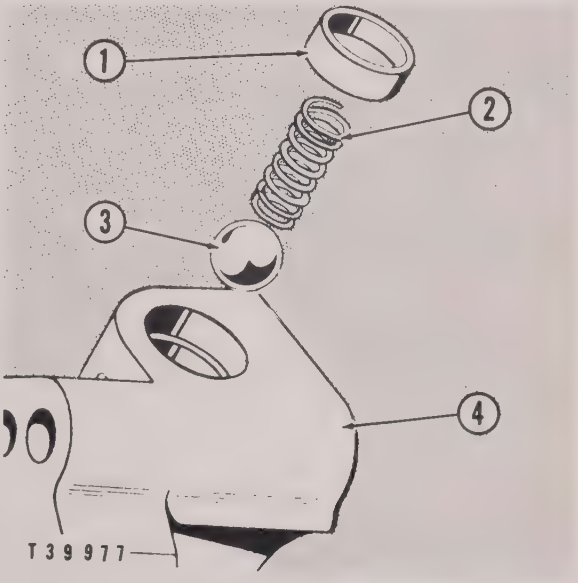
Pressure Regulating Valve

The oil pump contains a pressure regulating valve which is located within the pump body **(4)**.

The pressure setting is predetermined and requires no adjustment, since the pressure setting is maintained by spring tension.

The valve consists of the ball **(3)**, spring **(2)** and plug **(1)**. A ground seat in the pump body provides a seating surface for the ball **(3)**.

To remove the valve spring and ball, pry the plug **(1)** from the pump body and slide the spring and ball from the body.



PRESSURE REGULATING VALVE
1–Plug. 2–Spring. 3–Ball. 4–Pump body.

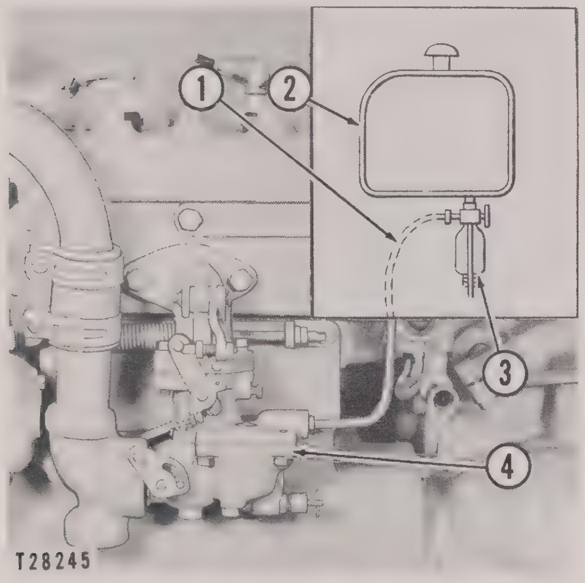
When installing the valve assembly, a new plug must be placed into the pump body with the open side of the plug turned outward. Drive the plug into the body until the outer edge of the plug is flush with the pump body.

Fuel System

The fuel system consists of the fuel tank **(2)**, fuel filter **(3)**, fuel line **(1)** and carburetor **(4)**.

The fuel flows from the fuel tank **(2)** to the carburetor **(4)** through the fuel line **(1)**. It is mixed with the proper proportions of air in the carburetor and delivered into the inlet manifold, past the inlet valves and into the cylinders where it is burned.

The fuel filter **(3)** contains a manually operated shutoff valve to stop the flow of fuel to the carburetor when the engine is not operating.



FUEL SYSTEM
1–Fuel line. 2–Fuel tank. 3–Fuel filter. 4–Carburetor.

CARBURETOR

An up-draft carburetor is used on this starting engine. The carburetor is sealed, protecting all the internal parts from dirt and moisture.

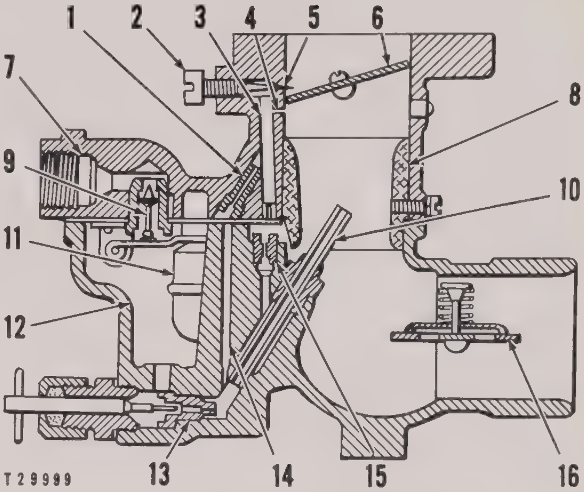
Operation

Fuel enters the carburetor at the inlet port **(7)** and is directed through the fuel valve **(9)** to the bowl **(12)**. The level of fuel in the bowl is regulated by the float assembly **(11)**.

NOTE

The fuel valve **(9)** does not open and close intermittently, but assumes an opening sufficient to maintain a proper level in the bowl, for the demand of the engine.

Fuel for idling enters the main jet **(13)** from the bowl **(12)**, is directed through the port **(14)**, and enters the idle jet **(1)**. The fuel mixes with air in the air passage **(3)**. Air for the fuel mixture enters the air passage **(3)** from a port behind the venturi **(8)**, and through the port **(4)**. The mixture flows up the passage around the needle of the idle adjusting screw **(2)**, through the port **(5)**, and to the carburetor air stream. As the throttle plate **(6)** is opened for faster idling speeds, the edge of the throttle plate **(6)** passes the port **(4)**. The fuel mixture then flows through the port **(4)** to the air stream.



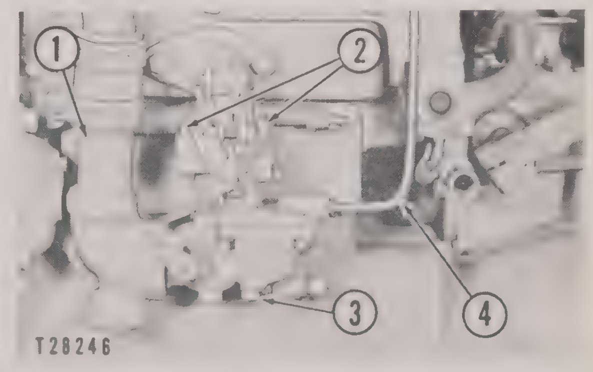
CARBURETOR OPERATION
1–Idle jet. 2–Idle adjusting screw. 3–Air passage. 4–Port. 5–Port. 6–Throttle plate. 7–Inlet port. 8–Venturi. 9–Fuel valve. 10–Discharge tube assembly. 11–Float assembly. 12–Bowl. 13–Main jet. 14–Port. 15–Well vent jet. 16–Choke plate.

During the high speed operation, the fuel flows from the bowl **(12)** to the main jet **(13)**. Air flows through the well vent jet **(15)** and mixes with the fuel in the main discharge tube assembly **(10)**. This mixture then flows through the tube to the air stream of the carburetor.

During the choking operation, the choke plate **(16)** closes the main air inlet passage of the carburetor. This action causes more fuel to flow from the main jet **(13)** to the main air passage.

Removal

1. Close the shutoff valve on the fuel filter and remove the fuel line **(4)**.
2. Remove the plug **(3)** and drain the fuel from the bowl.
3. Remove the bolts **(2)** which secure the carburetor to the elbow.



PREPARING TO REMOVE CARBURETOR
1–Air cleaner pipe. 2–Bolts. 3–Plug. 4–Fuel inlet line.

4. Remove the carburetor from the air cleaner pipe **(1)**.

Disassembly and Assembly of Carburetor

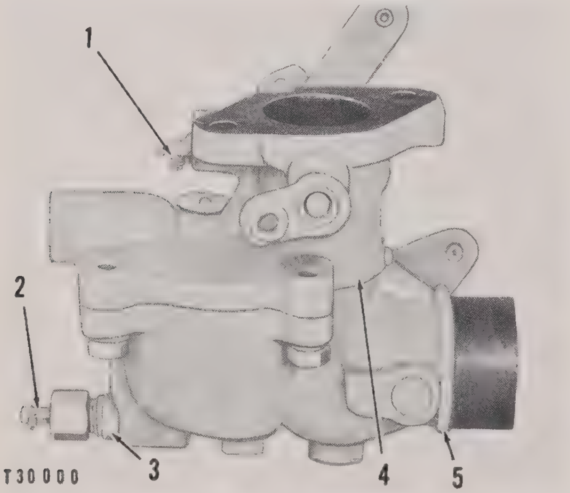
Special service tools mentioned by part number are available from Zenith Carburetor Division, Bendix Aviation Corp., Detroit, Michigan.

NOTE

Do not remove the round aluminum disc riveted to the top of the carburetor bowl cover. This disc specifies the assembly outline number to which the carburetor was originally built.

Body and Adjusting Screws

1. Remove the four screws securing the throttle body assembly **(4)** to the bowl assembly **(5)**.
2. Raise the throttle body slightly and loosen the gasket from the bowl assembly so the throttle body can be lifted off without damaging the floats.

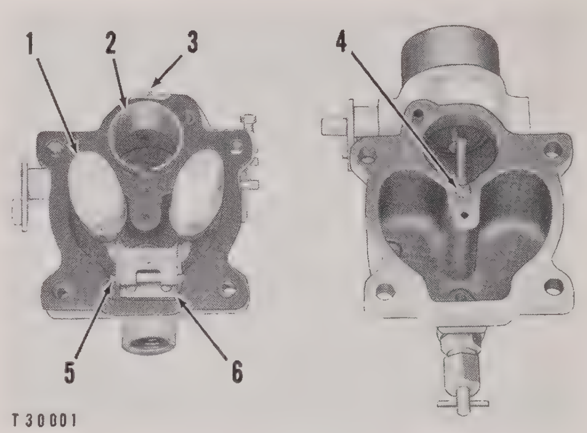


CARBURETOR DISASSEMBLY
1–Idle adjusting screw. 2–Main jet adjusting needle. 3–Fitting. 4–Throttle body assembly. 5–Bowl assembly.

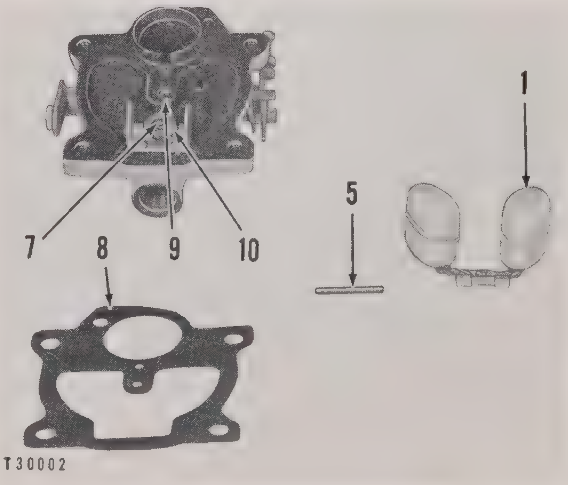
3. Remove the idle adjusting screw **(1)** and spring.
4. Remove the main jet adjusting needle **(2)** and the fitting **(3)**.

Removing Floats, Idle Jet, Well Jet and Venturi

1. Remove the float axle **(5)** using a screwdriver to push the axle from the slotted end of the bracket **(6)**, and the fingers to remove it the rest of the way.
2. Remove the float assembly **(1)**.
3. Remove the fuel valve needle **(7)**.
4. Remove the fuel valve seat **(10)** and gasket using the C161-82 Service Tool.
5. Remove the gasket **(8)**.
6. The well vent jet **(4)** can be removed using a screwdriver with a 3/16 inch blade.



CARBURETOR DISASSEMBLY
1–Float assembly. 2–Venturi. 3–Screw. 4–Well vent jet. 5–Float axle. 6–Bracket.

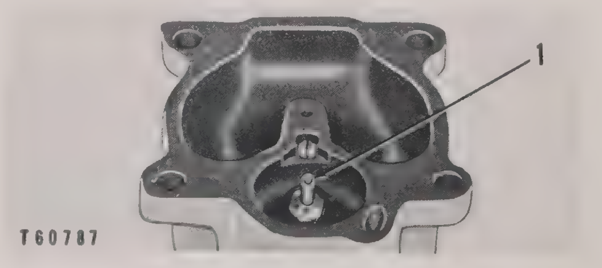


CARBURETOR DISASSEMBLY
1–Float assembly. 5–Float axle. 7–Fuel valve needle. 8–Gasket. 9–Idle jet. 10–Fuel valve seat.

7. The idle jet **(9)** can be removed with the same screwdriver used on the well vent jet.
8. Remove the screw **(3)**, and remove the venturi **(2)** from the throttle body assembly.

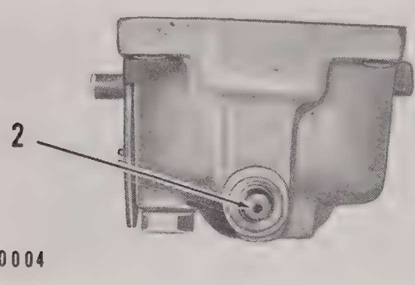
Removing Discharge Tube Assembly and Main Jet

Remove the main discharge tube assembly **(1)** and gasket from the bowl assembly.



CARBURETOR DISASSEMBLY
1–Main discharge tube assembly.

Remove the main jet **(2)** from the bottom of the bowl assembly where the main jet adjusting needle and fitting were removed previously.



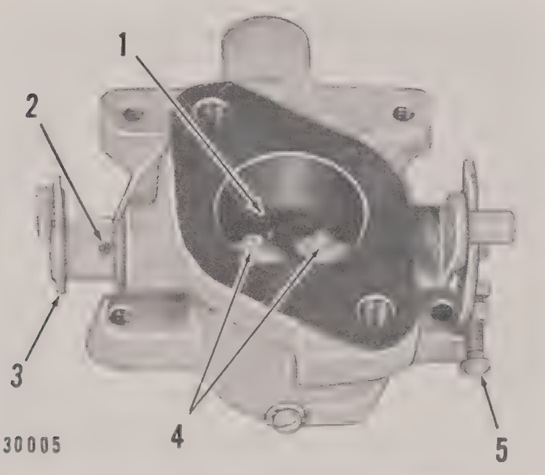
T30004

CARBURETOR DISASSEMBLY
2–Main jet.

Throttle Plate Assembly Removal

The throttle plate **(1)** can be removed by melting the solder from the two screws **(4)** securing it to the throttle shaft and removing the screws. After removing the throttle plate drive out the pin **(2)** securing the lever **(3)** to the throttle shaft. Remove the throttle shaft from the body. The throttle shaft is supported in the body by two bearings and has a seal at each end.

The throttle plate **(1)** is installed in the throttle body assembly in such a position that the idle adjusting port is above the throttle plate and the port leading from the metering well is directly under the throttle plate. These two ports are drilled after the throttle plate has been installed, and must remain in the same relative position in relation to the throttle plate. For this reason, the following procedure in removing and replacing the throttle plate must be closely followed.



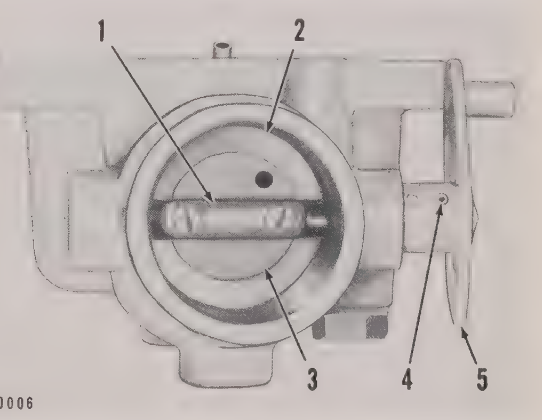
T30005

REMOVING THROTTLE PLATE ASSEMBLY
1–Throttle plate. 2–Pin. 3–Lever. 4–Screws.
5–Throttle stop screw.

Before removing the throttle plate, unscrew the throttle stop screw **(5)** to permit complete closing of the throttle plate. Hold the throttle in the tightly closed position and mark the throttle body along the top of the throttle plate with a steel scriber. This scribed line will be used as a guide when replacing the throttle plate or installing a new shaft. Should the new plate show a noticeable variation from the old one, select another new plate to get one that fits very closely to the scribed line when installed.

Choke Plate Assembly Removal

The choke plate **(2)** has a spring loaded poppet valve **(3)** built into it. This poppet valve is opened by the stream of air after the engine starts. This permits the engine to operate without flooding until the choke control rod can be pushed in.



T30006

CARBURETOR CHOKE PLATE DISASSEMBLY
1–Shaft. 2–Choke plate. 3–Poppet valve.
4–Tapered pin. 5–Control lever.

The choke plate can be removed by melting the solder from the two screws securing it to the shaft **(1)** and removing the screws. The shaft **(1)** can be removed by driving out the tapered pin **(4)** which secures the control lever **(5)** to the shaft. The shaft is supported by two bearings and has a seal at each end of the shaft. These bearings present the same problems as the throttle shaft bearings. See the topic, THROTTLE PLATE ASSEMBLY REMOVAL.

Choke Plate and Throttle Plate Assembly

Install the choke plate in the correct position, properly centering it before tightening and soldering the screws. The choke plate should be held wide open while installing the lever. Check the operation to make sure the choke plate closes and opens fully.

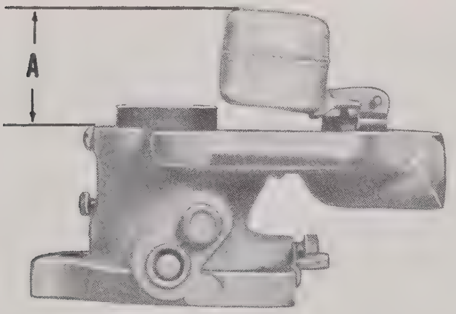
Install the throttle shaft and throttle plate. See the topic, THROTTLE PLATE ASSEMBLY REMOVAL. Install the stop lever assembly on the throttle shaft. When the throttle plate is straight up and down in the barrel, the stop lever should be against the stop pin. If the shaft is new, it will be necessary to drill a new hole in the shaft. Pin the stop lever to the shaft with a taper pin. Tighten and solder the two screws.

Replacing Jets

Replace the main jet using a new gasket. Install the discharge tube assembly along with a new gasket. Install the main jet adjusting needle assembly. Replace the well vent. No gasket is necessary. Install the idle jet. It does not require a gasket. Replace the fuel valve seat using a new gasket.

Replacing Floats and Venturi

1. Install the venturi in the throttle body, and install the small screw that secures it in place.
2. Place the fuel valve needle in the fuel valve seat and install the float assembly.
3. Install the float axle and bend the slotted bracket. The float should move freely on the axle.
4. Check the position of the float to obtain the correct fuel level as shown. The dimension **(A)** should be 1 5/32" ± 1/32".
5. Install the gasket that seals the throttle body to the bowl body.



T30007

FLOAT LEVEL
A–1 5/32" ± 1/32".

Assembling Throttle Body to the Bowl Assembly

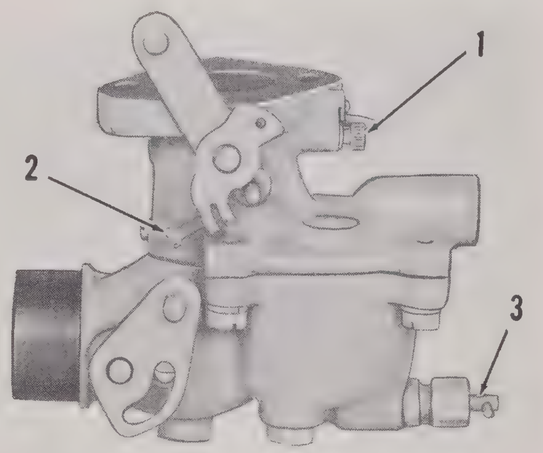
Place the bowl assembly in position on the throttle body being careful not to damage the float assembly.

Install the four screws and lockwashers; tighten them evenly.

Install the idle adjusting screw and spring.

Installing Carburetor and Making Final Adjustment

1. Install two new ring seals in the end of the air cleaner outlet pipe and slip the carburetor into position.
2. Install the two bolts securing the carburetor to the starting engine inlet manifold.
3. Connect the fuel line, choke control linkage and throttle control linkage.
4. As a preliminary adjustment, set the idle adjusting screw **(1)** and the main jet adjustment **(3)** at one full turn open, and adjust the throttle stop screw **(2)** to hold the throttle plate just slightly open.
5. A more accurate adjustment can be obtained while the engine is running by turning the main jet adjusting screw **(3)** out to make the mixture richer or in to make it leaner.
6. Adjust this screw to a point that will give the greatest amount of power with a clear exhaust.
7. Turn the idle adjusting screw **(1)** until the engine will idle regularly at a slow speed without emitting black smoke from the exhaust.
8. Turn this screw out to make the mixture richer or in to make it leaner.



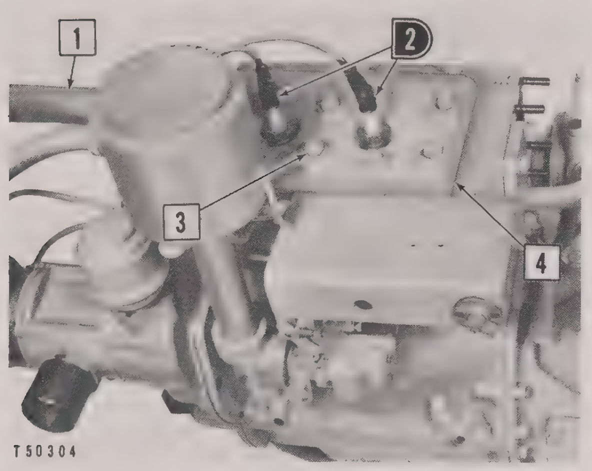
T30008

CARBURETOR ADJUSTMENT
(Carburetor removed from engine for better illustration)
1–Idle adjusting screw. 2–Throttle stop screw.
3–Main jet adjusting screw.

9. Turn the throttle stop screw **(2)** to the left (out) to decrease idling speed or to the right (in) to increase the speed.

Cylinder Head and Valves

CYLINDER HEAD REMOVAL AND INSTALLATION



REMOVAL OF CYLINDER HEAD

☐ Remove ● Disconnect

1–Front water line. 2–Ignition wires. 3–Bolts. 4–Cylinder head.

Remove all carbon from the head and block assembly, install a new gasket and install in reverse order of removal.

Tighten the bolts **(3)** to the torque value given in the topic, SPECIFICATIONS.

VALVES AND VALVE MECHANISM

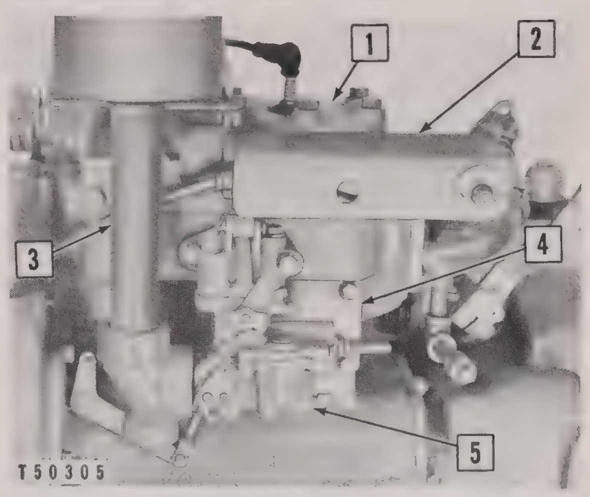
Compression pressure losses occur when the valve faces and seats become pitted. Valves should be checked occasionally to see that they are seating properly. This can be done by rocking the starting engine against compression. If the cylinder head gasket and piston rings are in good condition and the engine does not rock back against compression, it is likely that the valves and seats should be refaced and reground.

Preparation for Valve Mechanism Removal

Remove the starting engine from the diesel engine.

NOTE

When installing the inspection plate, be sure that the four copper washers are correctly placed at the through-drilled holes.



PREPARING TO REMOVE VALVE MECHANISM

☐ Remove

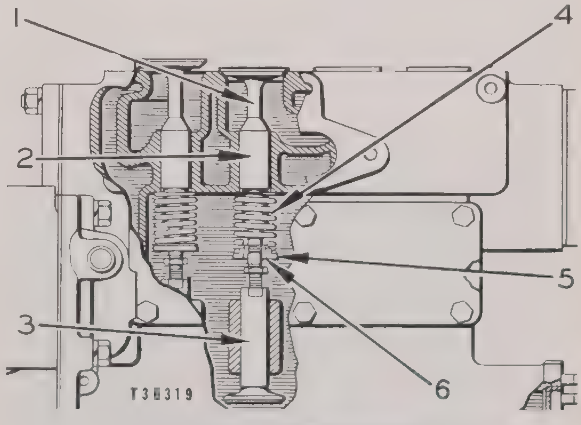
1–Cylinder head. 2–Bracket. 3–Air cleaner pipe. 4–Inspection plate. 5–Carburetor.

Valve Mechanism Removal

With a valve spring compressor tool, compress the spring **(4)** until the locks **(6)** can be removed from the retainer **(5)**. Lift out the valve **(1)** and remove the retainer and spring.

Inspect the valve seats in the cylinder block and the faces of the valves. Recondition them if necessary and check them as outlined in the diesel engine section. If the faces of the valves are pitted or warped, they should be replaced with new valves.

Clearances and wear limits for the valves are given in the topic, SPECIFICATIONS.



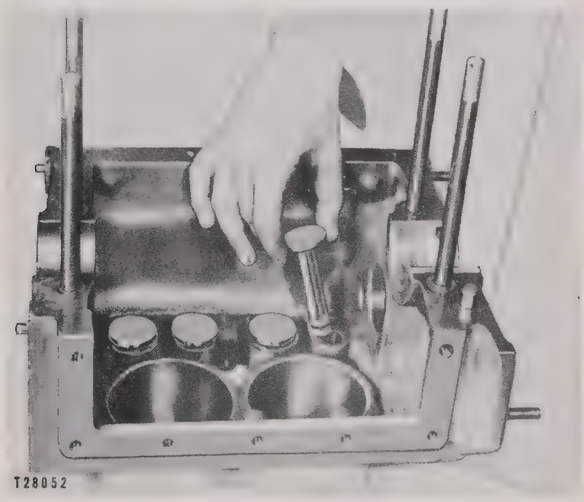
VALVE MECHANISM REMOVAL

1–Valve. 2–Guide. 3–Lifter. 4–Spring. 5–Retainer. 6–Lock.

Remove the camshaft as described in the topic, CAMSHAFT. Remove the lifters **(3)**. Then using a drift, shaped to fit the bore of the guide **(2)**, drive each guide down out of the cylinder block.

VALVE LIFTER REMOVAL AND INSTALLATION

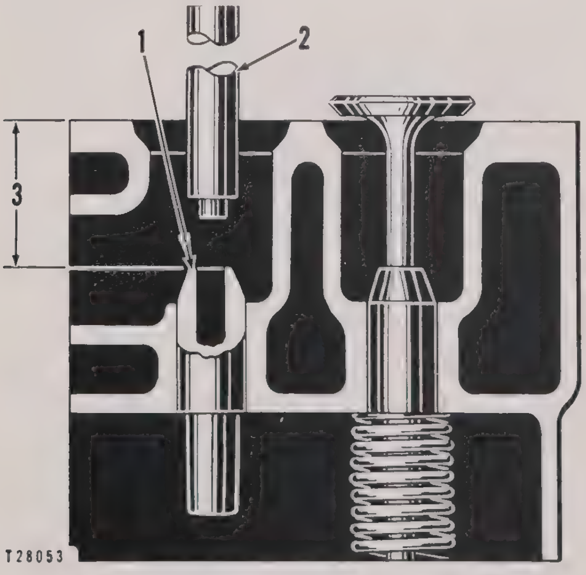
The lifters can be removed as shown, after the camshaft has been removed. See the topic, CAMSHAFT.



LIFTER REMOVAL

Make sure the lifters travel freely in the guide bore of the cylinder block. For adjustment see the topic, VALVE CLEARANCE ADJUSTMENT.

Replacing Valve Guides



INSTALLING VALVE GUIDE
1–Guide. 2–Inserting tool. 3–1 3/16".

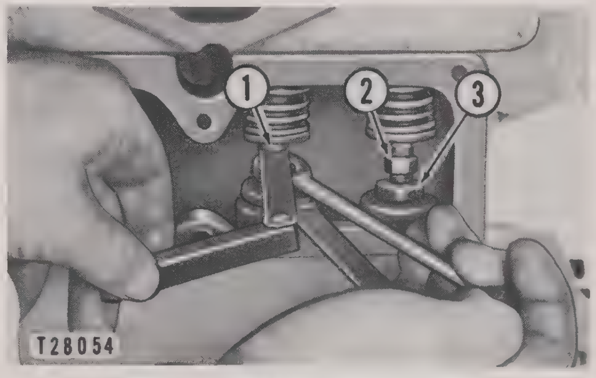
New replacement guides **(1)** are finished to the proper bore dimension and require no reaming after installation. When installing new guides, press them down into the cylinder block with the inserting tool **(2)** until the top of each guide is 1 3/16" below the top of the cylinder block or the distance **(3)**.

Carefully clean the parts of the valve mechanism before they are reassembled. When reassembling the valve mechanism, see that the locks are correctly installed in the lock retainer. Installation can be facilitated by coating the inside of the locks with heavy grease.

Valve Clearance Adjustment

A correct valve clearance adjustment can be made only while the engine is hot. However, if the valve mechanism has been removed, or changed in any way, the clearance should be adjusted in the following manner before operating the engine.

1. Crank the engine until the valve closes and the valve lifter is at its lowest point.
2. Hold the flat section **(3)** of the valve lifter to prevent it from turning, while a second wrench is used to turn the adjusting screw **(2)** until the correct clearance between the end of the valve **(1)** and the head of the adjusting screw is obtained. See the topic, SPECIFICATIONS.



VALVE CLEARANCE ADJUSTMENT
1–Valve. 2–Adjusting screw. 3–Valve lifter.

3. Tighten the locknut and check the adjustment.
4. This adjustment should be rechecked while the engine is hot. See the topic, SPECIFICATIONS, for correct clearance.

Pistons, Rings and Connecting Rods

PISTONS

Piston clearance should be measured by a thickness gauge on the thrust side of the piston. For the piston skirt clearance of a new piston see the topic, SPECIFICATIONS.

The piston surfaces and ring grooves should be thoroughly cleaned before installing rings or replacing the piston in the cylinder. The most satisfactory method of cleaning pistons is outlined in the diesel engine topic, INSPECTING AND CLEANING PISTONS.

CHECKING PISTON CLEARANCE

An engine that has shown a loss of power, excessive oil consumption and loss of compression may need to have the cylinder bores reconditioned.

While the piston is removed, it is good practice to measure the cylinder bore for possible out-of-roundness and wall taper. If the out-of-roundness and wall taper of the cylinder bore exceeds the value given in the topic, SPECIFICATIONS, the cylinder bore should be reconditioned and new pistons and rings installed.

Oversize pistons are available should it become necessary to recondition the cylinder bore. For piston size and corresponding cylinder bore diameter, see the chart in the topic, SPECIFICATIONS.

RINGS

To prevent breaking or distorting of rings and damaging ring grooves a piston ring expander should be used when removing or replacing rings in the grooves.

After rings have been installed on the pistons, they should be free in the grooves so they can be rotated without binding. For the proper side clearance of new rings see the topic, SPECIFICATIONS.

The ring gap of new rings should be measured at the smallest diameter of the cylinder bore. See the topic, SPECIFICATIONS, for the proper ring gap of new piston rings.

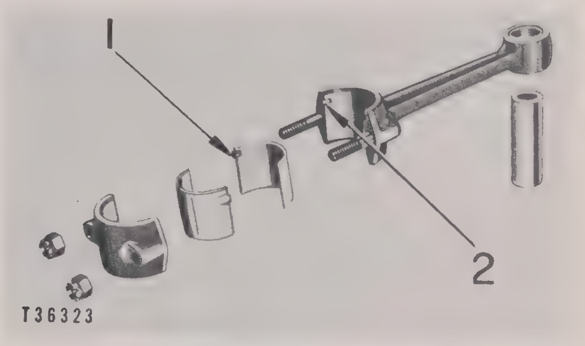
CONNECTING RODS

Connecting Rod Bearings

Precision bearings are used. These bearings do not require fitting and can be removed, inspected, and replaced through the inspection opening of the crankcase pan and cylinder block. For new bearing clearances, see the topic, SPECIFICATIONS.

When replacing the bearings, be sure the protruding portion **(1)** on the back of each bearing half lines up with its corresponding groove **(2)** in the connecting rod and bearing cap. This locks the bearing in place and keeps it from rotating.

Tighten the nuts on the bolts, which secure the connecting rod bearing caps to the torque value listed in the topic, SPECIFICATIONS.



CONNECTING ROD ASSEMBLY
1–Protruding portion on back of bearing. 2–Groove.

Piston Pin Bearings

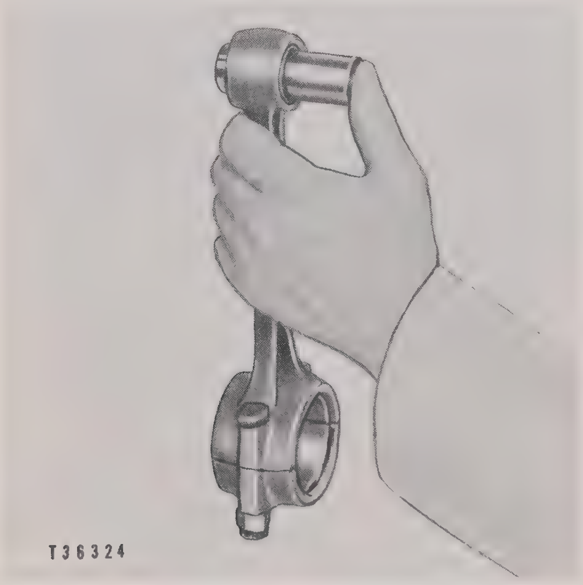
It is not always necessary to replace piston pin bearings when new connecting rod bearings are installed. In many cases, piston pin bearings may be serviceable even though the second replacement of connecting rod bearings has been made.

CHECKING PISTON PIN BEARING

After the oil has been removed from the pin and bearing, it is possible to feel the clearance between them. For the maximum allowable clearance between the bearing and pin, see the topic, SPECIFICATIONS.

A piston pin bearing furnished from stock must be finished to the correct size after it is pressed into the connecting rod, and the oil hole drilled. For the proper bore diameter see the topic, SPECIFICATIONS.

New connecting rods have the piston pin bearing bored in a special machine which maintains the proper center-to-center distance of the connecting rod bearing and piston pin bore. Reconditioned rods should be machined in the same manner. A new connecting rod makes a good template for center-to-center distance. For the correct center-to-center distance, see the topic, SPECIFICATIONS.



CHECKING PISTON PIN FIT

The piston pin should be a thumb push fit in the connecting rod pin bearing and piston bore at normal room temperature (70° F.). The piston pin should never be forced into the piston. For the proper clearance between the piston pin and the piston, see the topic, SPECIFICATIONS.

Piston assemblies should be replaced in the same cylinders from which they were removed. To assure correct assembly into the engine, the connecting rods are marked with the numbers 1 and 2, on the connecting rod pad. The rods are to be installed into the engine with the number on the rod pad turned toward the inspection opening of the oil pan. Cylinder number one is located at the timing gear end of the engine.

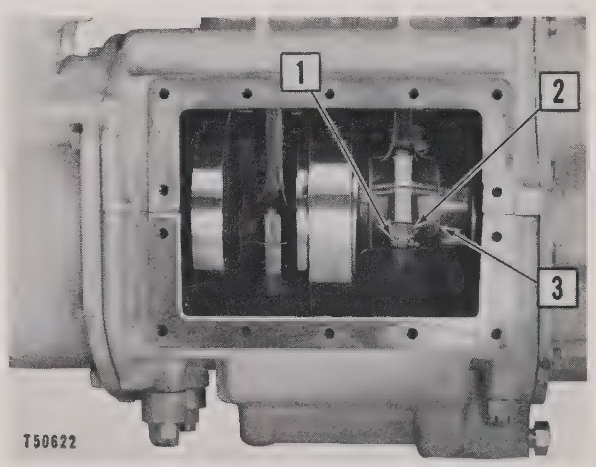
Piston and Connecting Rod Removal with the Oil Pan Installed

1. Remove the starting engine from its point of installation. See the covering topic.
2. Remove the inspection plate so the connecting rods can be checked.

NOTE

If the connecting rods and pistons only are to be removed, they can be removed in the following manner.

3. Remove the head. See the topic, CYLINDER HEAD REMOVAL AND INSTALLATION.
4. Rotate the crankshaft so that one of the crankshaft journals is nearest the inspection opening in the block.

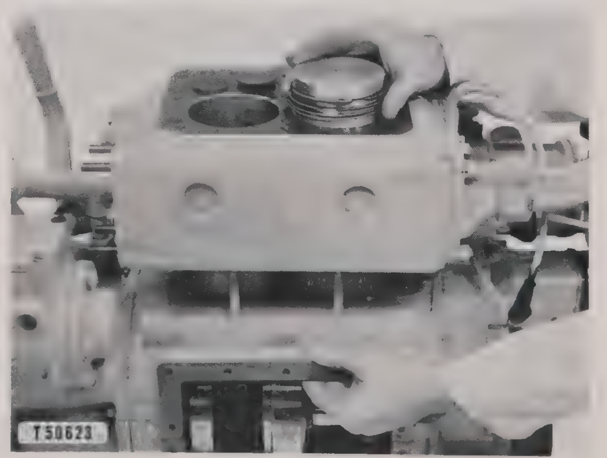


CONNECTING ROD BEARING CAP REMOVAL

☐ Remove

1–Cotter pin (two). 2–Nut (two). 3–Connecting rod cap.

5. Remove the piston and connecting rod through the top of the cylinder block.
6. Rotate the crankshaft 180° and remove the other piston in a like manner.



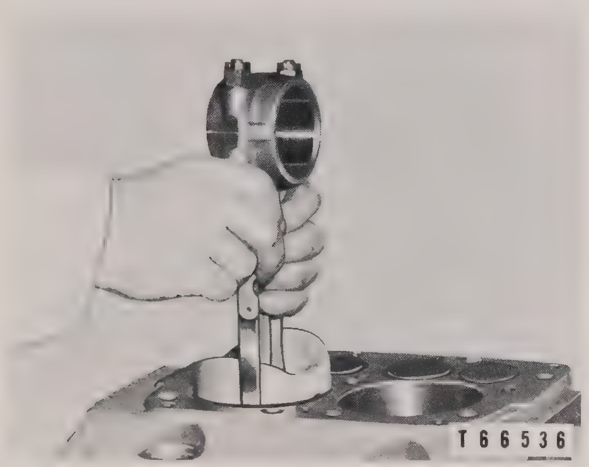
PISTON REMOVAL

Pistons, Rings and Connecting Rods

PISTONS

Piston clearance should be measured by a thickness gauge on the thrust side of the piston. For the piston skirt clearance of a new piston see the topic, SPECIFICATIONS.

The piston surfaces and ring grooves should be thoroughly cleaned before installing rings or replacing the piston in the cylinder. The most satisfactory method of cleaning pistons is outlined in the diesel engine topic, INSPECTING AND CLEANING PISTONS.



CHECKING PISTON CLEARANCE

An engine that has shown a loss of power, excessive oil consumption and loss of compression may need to have the cylinder bores reconditioned.

While the piston is removed, it is good practice to measure the cylinder bore for possible out-of-roundness and wall taper. If the out-of-roundness and wall taper of the cylinder bore exceeds the value given in the topic, SPECIFICATIONS, the cylinder bore should be reconditioned and new pistons and rings installed.

Oversize pistons are available, should it become necessary to recondition the cylinder bore. For piston size and corresponding cylinder bore diameter, see the chart in the topic, SPECIFICATIONS.

RINGS

To prevent breaking or distorting of rings and damaging ring grooves a piston ring expander should be used when removing or replacing rings in the grooves.

After rings have been installed on the pistons, they should be free in the grooves so they can be rotated without binding. For the proper side clearance of new rings see the topic, SPECIFICATIONS.

The ring gap of new rings should be measured at the smallest diameter of the cylinder bore. See the topic, SPECIFICATIONS, for the proper ring gap of new piston rings.

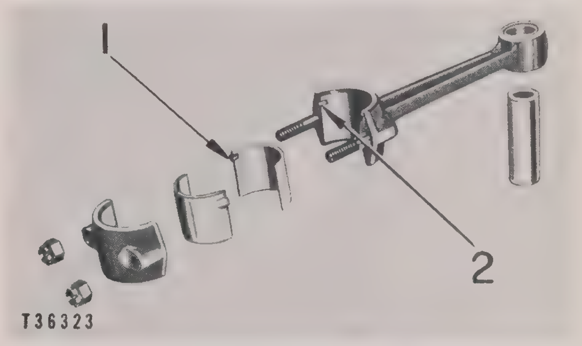
CONNECTING RODS

Connecting Rod Bearings

Precision bearings are used. These bearings do not require fitting. The oil pan must be removed before inspection or replacement is possible. For new bearing clearances, see the topic SPECIFICATIONS.

When replacing the bearings, be sure the protruding portion **(1)** on the back of each bearing half lines up with its corresponding groove **(2)** in the connecting rod and bearing cap. This locks the bearing in place and keeps it from rotating.

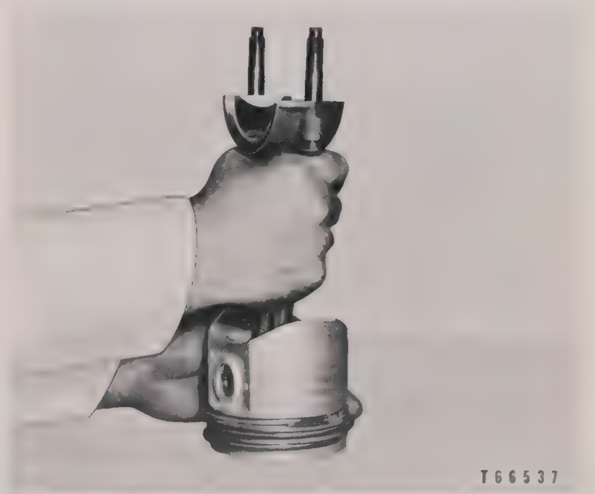
Tighten the nuts on the bolts, which secure the connecting rod bearing caps to the torque value listed in the topic, SPECIFICATIONS.



CONNECTING ROD ASSEMBLY
1–Protruding portion on back of bearing. 2–Groove.

Piston Pin Bearings

It is not always necessary to replace piston pin bearings when new connecting rod bearings are installed. In many cases, piston pin bearings may be serviceable even though the second replacement of connecting rod bearings has been made.



CHECKING PISTON PIN BEARING

After the oil has been removed from the pin and bearing, it is possible to feel the clearance between them. For the maximum allowable clearance between the bearing and pin, see the topic, SPECIFICATIONS.

A piston pin bearing furnished from stock must be finished to the correct size after it is pressed into the connecting rod, and the oil hole drilled. For the proper bore diameter see the topic, SPECIFICATIONS.

New connecting rods have the piston pin bearing bored in a special machine which maintains the proper center-to-center distance of the connecting rod bearing and piston pin bore. Reconditioned rods should be machined in the same manner. A new connecting rod makes a good template for center-to-center distance. For the correct center-to-center distance, see the topic, SPECIFICATIONS.

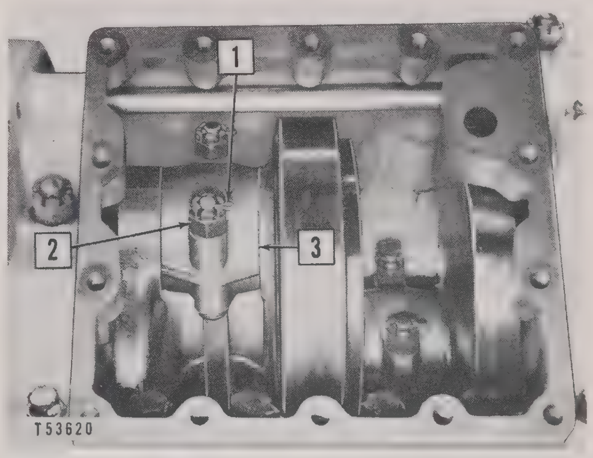
CHECKING PISTON PIN FIT

The piston pin should be a thumb push fit in the connecting rod pin bearing and piston bore at normal room temperature (70° F.). The piston pin should never be forced into the piston. For the proper clearance between the piston pin and the piston, see the topic, SPECIFICATIONS.

Piston assemblies should be replaced in the same cylinders from which they were removed. To assure correct assembly into the engine, the connecting rods are marked with the numbers 1 and 2, on the connecting rod pad. The rods are to be installed into the engine with the number on the rod pad turned toward the inspection opening of the oil pan. Cylinder number one is located at the timing gear end of the engine.

Piston and Connecting Rod Removal

1. Remove the starting engine from the machine and mount on repair stand upside down.
2. Remove the oil pan sump so the connecting rods can be checked.
3. Remove head. See the topic, CYLINDER HEAD REMOVAL AND INSTALLATION.
4. Rotate the crankshaft so one of the crankshaft journals is accessible through the opening in the bottom of the block.

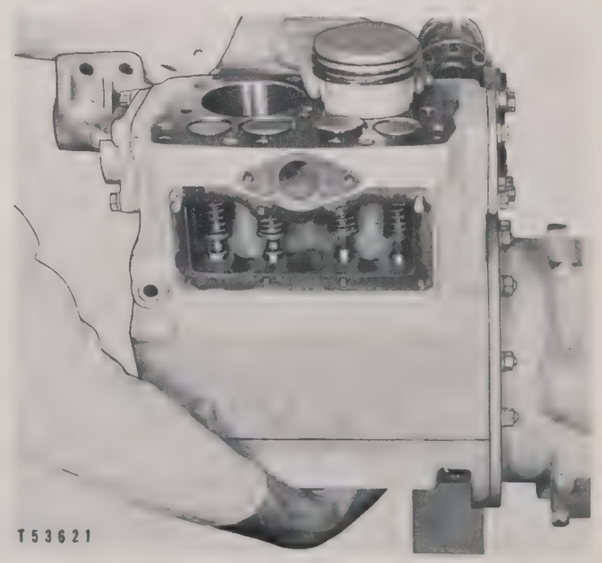


CONNECTING ROD BEARING CAP REMOVAL

☐ Remove

1–Cotter pin. 2–Nut. 3–Connecting rod cap.

5. Turn the engine over and remove the piston and connecting rod through the top of the cylinder block.
6. Rotate the crankshaft 180° and remove the other piston in a like manner.



PISTON REMOVAL

Timing Gear Housing

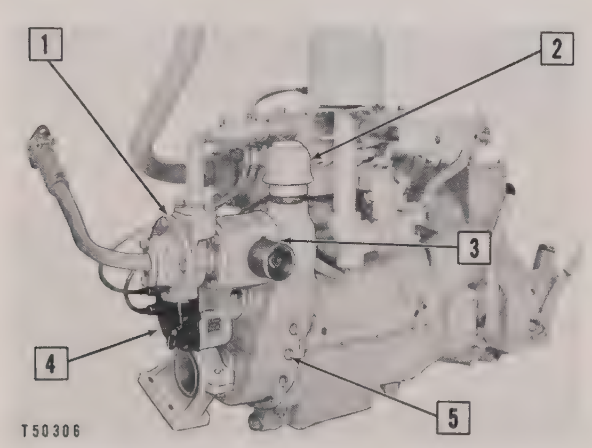
The timing gear housing is located at the front of the starting engine block. It has mounted on, or within it, the hand crank mechanism, magneto and governor. The housing also houses the oil pump which is mounted on the forward end of the engine oil pan.

A bevel gear located on the end of a shaft, opposite the hand crank mechanism drive gear, is engaged with the hand crank bevel gear to permit manual starting of the engine. The hand crank mechanism drive gear drives the camshaft gear and cranks the engine. The hand crank mechanism can be mounted either vertically or horizontally to better adapt it for all cranking conditions. The magneto drive is integral with the camshaft gear.

TIMING GEAR HOUSING REMOVAL AND INSTALLATION

The timing gear housing can be removed from the starting engine, with the engine mounted on or removed from the diesel engine.

The following procedure describes removal of the housing with the starting engine removed from the diesel engine.



PREPARING TO REMOVE TIMING GEAR HOUSING

☐ Remove

1–Water pump. 2–Breather. 3–Hand crank mechanism. 4–Magneto. 5–Bolts.

For removal procedures of the water pump **(1)**, hand crank mechanism **(3)**, and the magneto **(4)**, see the covering topics.

NOTE

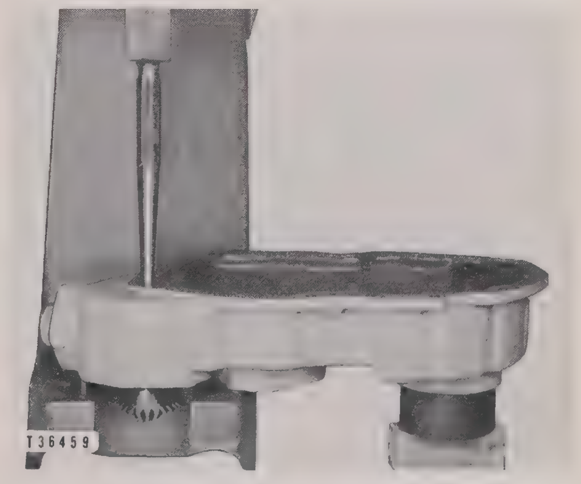
If removal is to be accomplished with the starting engine installed on the diesel engine, support the forward end of the starting engine oil pan. Remove the bolts securing the starting engine front support bracket to the diesel engine and proceed to remove the timing gear housing.

REMOVING THE TIMING GEAR HOUSING

Install in reverse order of removal, replacing all worn or damaged gaskets.

DISASSEMBLY AND ASSEMBLY

Press the shaft and bevel gear from the drive gear as shown.



REMOVING SHAFT AND BEVEL GEAR

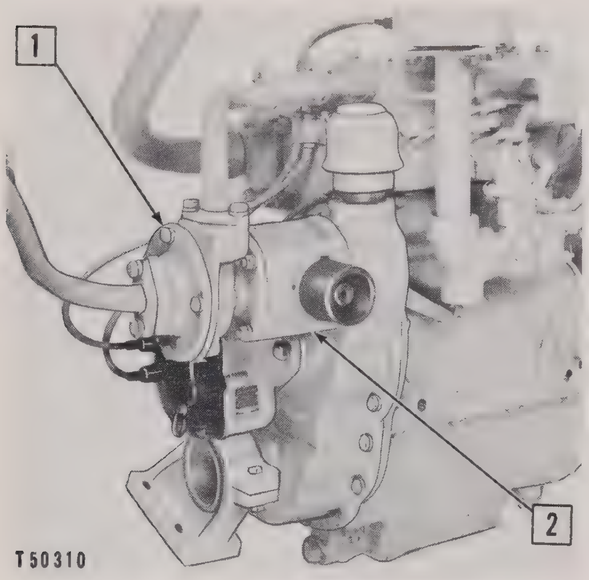
Press the shaft from the bevel gear in a similar manner.

Install in reverse order of removal.

HAND CRANK MECHANISM

Removal and Installation

Remove the starting engine water pump **(1)**. See the covering topic.

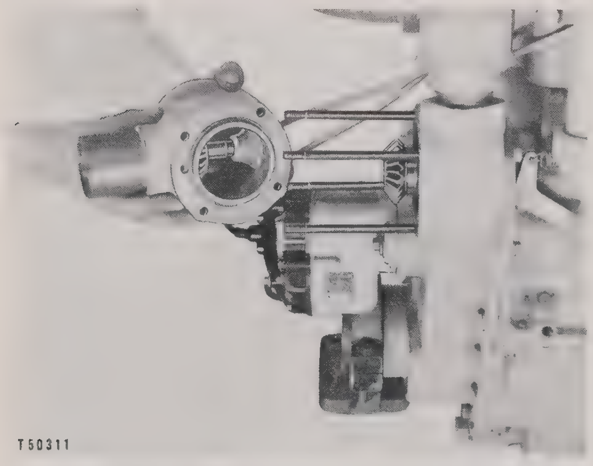


PREPARING TO REMOVE THE HAND CRANK MECHANISM

☐ Remove

1–Water pump. 2–Hand crank mechanism.

Remove the hand crank mechanism **(2)**, as illustrated.

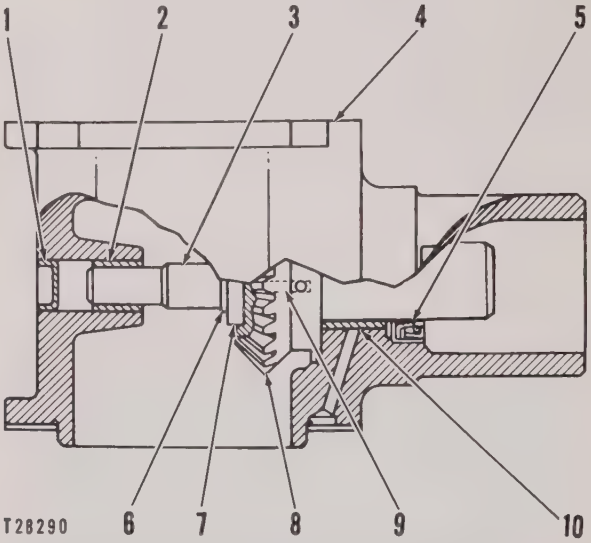


REMOVING THE HAND CRANK MECHANISM

Install in the reverse order of removal, replacing all damaged gaskets.

Disassembly and Assembly

1. Remove the snap ring **(6)** from the groove in the shaft **(3)**.
2. Remove the plug **(1)** from the housing **(4)**.
3. Insert a suitable spacer through the opening from which the plug **(1)** was removed and drive or press the shaft **(3)** from the gear **(8)**.



HAND CRANK MECHANISM CROSS-SECTION
1–Plug. 2–Bearing. 3–Shaft. 4–Housing. 5–Seal. 6–Ring. 7–Washer. 8–Gear. 9–Key. 10–Bearing.

4. Remove the shaft, gear, snap ring and washer **(7)** from the housing.
5. Remove the key **(9)** from the shaft.
6. Inspect the seal **(5)** and the sleeve bearings **(2)** and **(10)** and replace if worn or damaged. The seal must be pressed into the housing with the sealing edge pointed outward.
7. Assemble in the reverse order of disassembly.

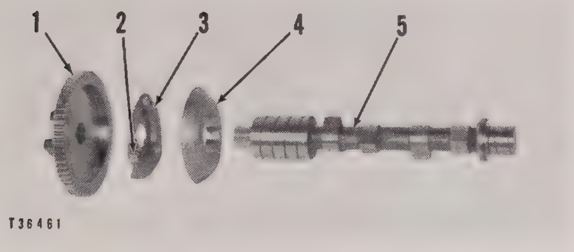
GOVERNOR

The governor consists of three ball weights, a ramp, a yoke and a governor spring. The tension of the governor spring tends to open the carburetor throttle plate and the force generated by the rotating ball weights tends to close the throttle plate.

When the opposing governor forces are equal, a constant amount of fuel mixture is admitted to the cylinders and the engine will operate at a constant speed. See the topic, STARTING ENGINE OPERATION, for further information on the governor operation.

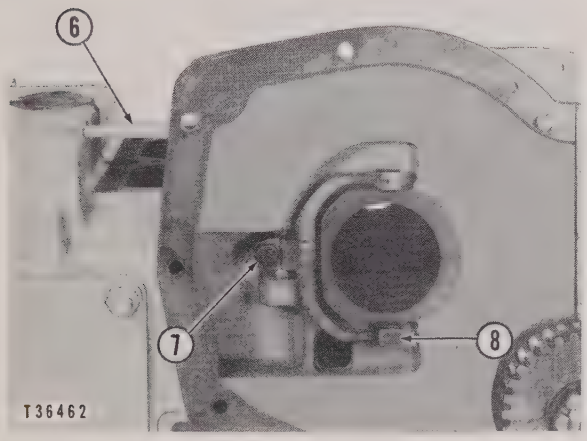
Governor Removal and Disassembly

1. Remove the camshaft **(5)**, driver **(3)** and ramp **(4)** from the cylinder block. See the topic, CAMSHAFT REMOVAL SEPARATELY. Be careful not to lose the three ball weights **(2)**.
2. Press the camshaft **(5)** from the camshaft gear **(1)** and remove the driver **(3)**. See the topic, CAMSHAFT GEAR REMOVAL AND INSTALLATION.



GOVERNOR DISASSEMBLY
1–Camshaft gear. 2–Ball weight. 3–Driver. 4–Ramp. 5–Camshaft.

3. Remove the yoke **(8)** and the lever assembly **(6)** from the block by loosening the bolt **(7)** and sliding the lever assembly out of the block.

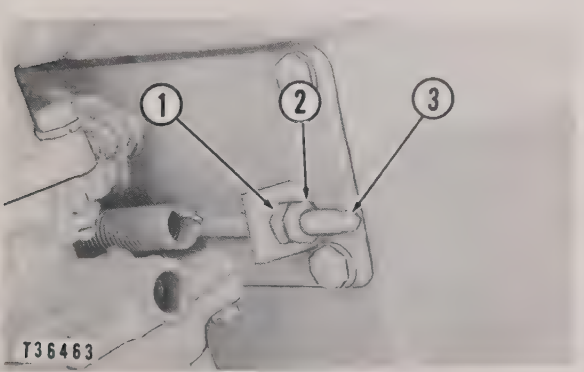


REMOVING GOVERNOR LEVER ASSEMBLY
6–Lever assembly. 7–Bolt. 8–Yoke.

4. Install the governor in the reverse order of removal.

Governor Adjustment

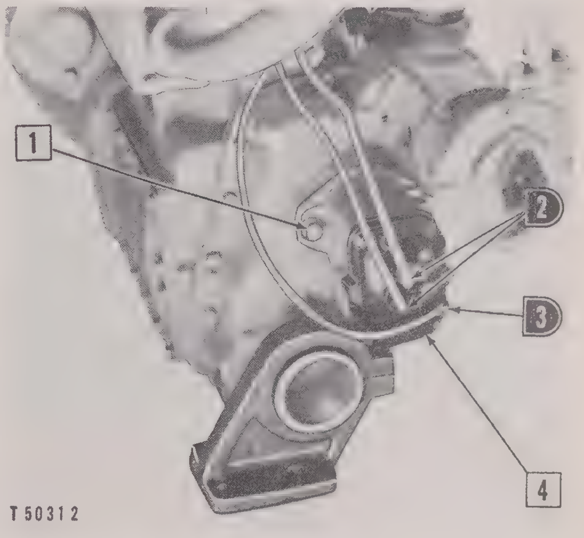
High idle adjustment is made by tightening or loosening the nut **(1)** on the adjusting screw **(3)** to obtain the desired engine speed of 2950 RPM. This can be checked with a hand tachometer on the outer end of the shaft in the hand crank mechanism, which rotates at actual engine speed. After the proper adjustment has been made, lock the adjusting nut **(1)** with the locknut **(2)**.



ADJUSTING THE GOVERNOR
1–Adjusting nut. 2–Locknut. 3–Adjusting screw.

MAGNETO

Removal and Installation



PREPARING TO REMOVE MAGNETO
☐ Remove ◗ Disconnect
1–Bolts. 2–Spark plug wires. 3–Switch lead. 4–Magneto.

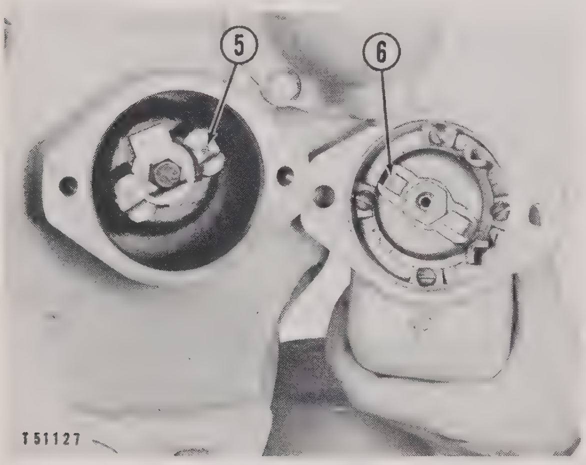
Tag the spark plug wires **(2)** so they can be correctly identified when the magneto is installed.

REMOVING MAGNETO

NOTE

The spark plug wire from the number 1 cylinder (the cylinder farthest from the flywheel) goes to the number 1 receptacle in the magneto cap.

Install in reverse order of removal, aligning the X-marks on the magneto drive **(5)** and impulse coupling drive **(6)** for proper timing.



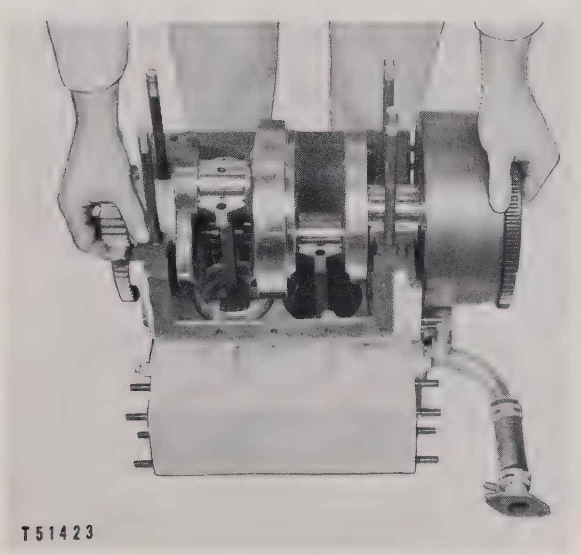
TIMING THE MAGNETO
5–X-mark on the magneto drive. 6–X-mark on the impulse coupling drive.

Crankshaft, Flywheel and Main Bearings

CRANKSHAFT

Removal and Installation

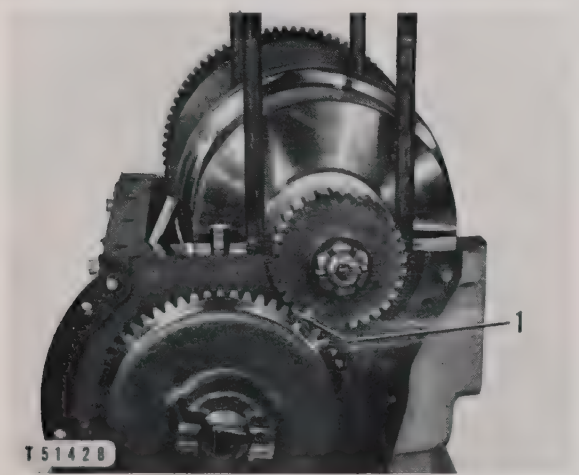
1. Remove the starting engine and remove the clutch and transmission housing. See the covering topics.
2. Remove the oil pan and connecting rod bearing caps. See the covering topics.
3. The crankshaft, with or without the flywheel installed, can be removed as shown.



CRANKSHAFT REMOVAL

CAUTION

When installing the crankshaft assembly into the cylinder block, the front main bearing dowel hole must fit over the dowel pin in the cylinder block.

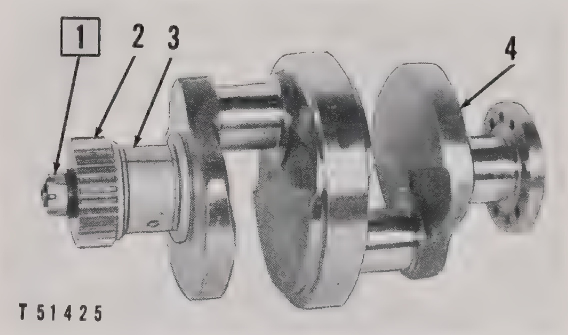


ENGINE TIMING
1–Timing marks.

4. Align the camshaft gear and crankshaft gear timing marks (**1**) when installing the crankshaft.

Disassembly and Assembly

1. Remove the flywheel. See the covering topic.

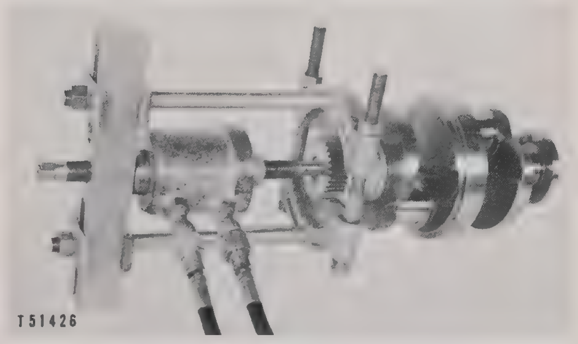


CRANKSHAFT GEAR REMOVAL

☐ **Remove**

1–Nut. 2–Crankshaft gear. 3–Front main bearing. 4–Crankshaft.

2. Using an 8B7548 Push Puller, an 8B7551 Bearing Pulling Attachment, and a 7F9540 Hydraulic Puller with the 6F25 Pump Group, pull the crankshaft gear (**2**) from the crankshaft (**4**), as shown.



PULLING CRANKSHAFT GEAR

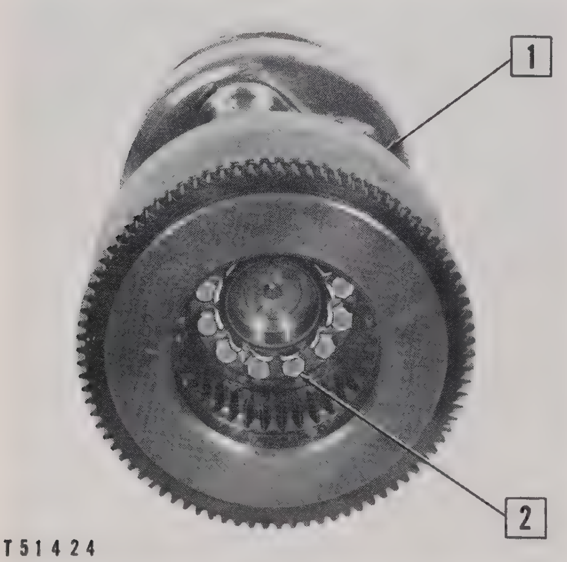
3. Remove the key and main bearing (**3**).
4. Check the bearing journals for wear. See the topics, SPECIFICATIONS and MAIN BEARINGS.
5. Check the oil passages to be sure they are all open.
6. Heat the crankshaft gear (**2**) to a temperature not to exceed 600° F. and install with the chamfered edge inward.

7. Tighten the crankshaft gear retaining nut to the torque value as listed in the topic, SPECIFICATIONS.
8. Check the main bearing end clearance. See the topic, SPECIFICATIONS, for correct and permissible end clearance.

FLYWHEEL

Removal and Installation

Remove the starting engine and remove the starting engine clutch and transmission housing. See the covering topics.



FLYWHEEL REMOVAL

☐ Remove

1–Flywheel. 2–Lock and bolts (twelve).

NOTE

The flywheel can be removed with the crankshaft in the engine if desired.

Tighten the flywheel bolts evenly and diametrically to the torque value given in the topic, SPECIFICATIONS.

Disassembly and Assembly

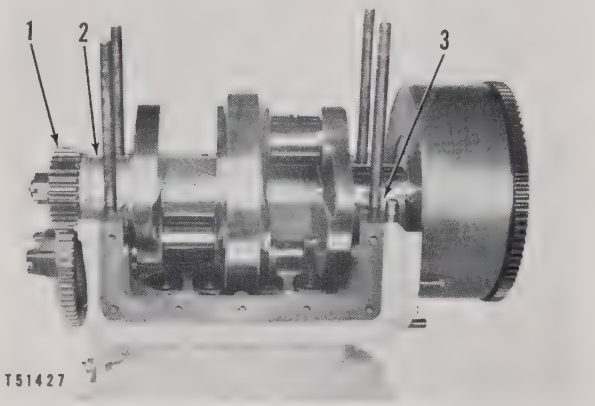
1. Press, cut or burn the ring gear from the flywheel.
2. Clean the ring gear and flywheel and remove all burrs.
3. Heat the ring gear to a temperature not to exceed 600° F., and install it on the flywheel.

NOTE

Make certain the double chamfered portion of the teeth on the ring gear is to the rear of the flywheel.

MAIN BEARINGS

This engine has two main bearings **(2)** and **(3)**. The rear main bearing **(3)** is a split-type consisting of two halves, upper and lower. The front main bearing **(2)** is a one-piece, flange type and takes the thrust of the crankshaft. The front main bearing can be removed only after the crankshaft has been removed from the engine and the gear **(1)** has been removed.



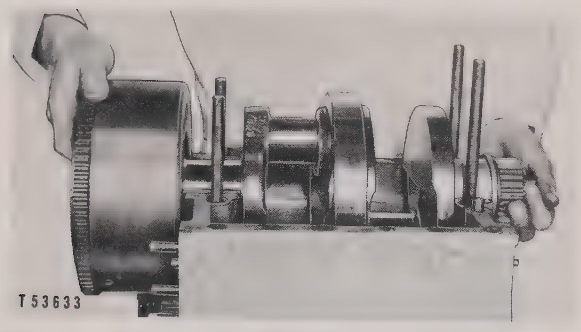
MAIN BEARINGS
1–Crankshaft gear. 2–Front main bearing. 3–Rear main bearing.

See the topic, SPECIFICATIONS, for permissible bearing clearance.

CRANKSHAFT

Removal and Installation

1. Mount the starting engine on a repair stand and remove the clutch and timing gear housings. See covering topics.
2. Remove oil pan sump, oil pan and connecting rod caps. See covering topics.
3. The crankshaft, with or without the flywheel installed, can be removed as shown.



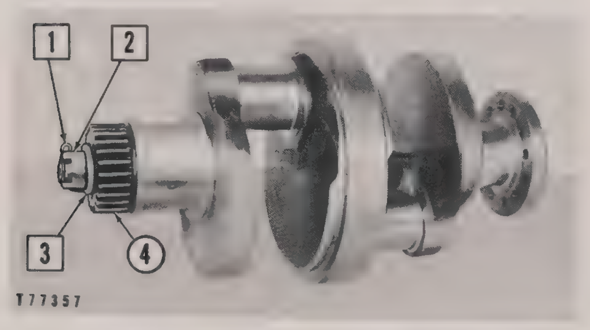
REMOVING CRANKSHAFT

CAUTION

Install crankshaft assembly into cylinder block with front main bearing dowel pin holes over dowel pin in the cylinder block.

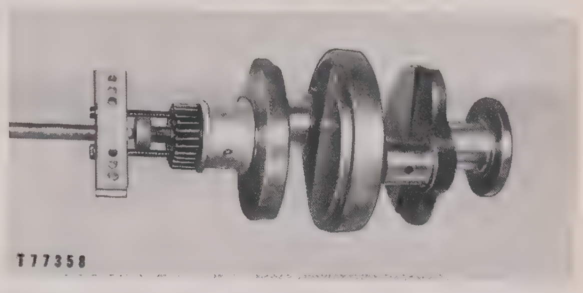
4. Install the crankshaft with timing mark on crankshaft gear aligned with timing mark on camshaft idler gear.

Disassembly and Assembly

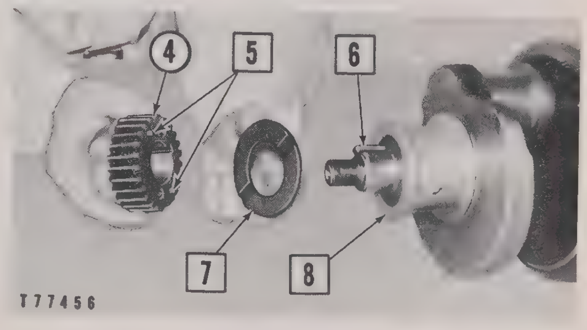


PREPARING TO REMOVE CRANKSHAFT GEAR
1–Cotter pin. 2–Nut. 3–Washer. 4–Crankshaft gear.

1. Pull crankshaft gear **(4)** from crankshaft.
2. Check the bearing journals for wear. See the SPECIFICATIONS and topic MAIN BEARINGS.
3. Check oil passages to be sure they are open.
4. Install front main bearing **(8)** and key **(6)**.
5. Install pins **(5)** in gear **(4)** and assemble washer **(7)** to gear.



REMOVING CRANKSHAFT GEAR
Tools required: 5F7465 Puller; two 5/16" - 18 NC bolts, 4" long; a step plate, 1.38" diameter and .50" thick; and two flat washers.

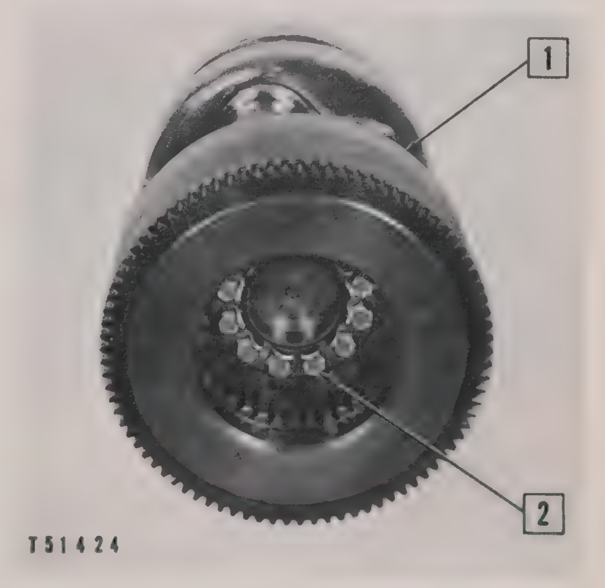


DISASSEMBLING CRANKSHAFT
4–Crankshaft gear. 5–Pins (two). 6–Key. 7–Washer. 8–Front main bearing.

6. Install gear and washer on crankshaft.
7. Install washer **(3)** and nut **(1)**. Tighten nut to torque value given in the SPECIFICATIONS.

FLYWHEEL

Removal and Installation



FLYWHEEL REMOVAL
1–Flywheel. 2–Lock and bolts (twelve).

Remove the starting engine and remove the starting engine clutch and pinion housing. See covering topics.

NOTE

The flywheel can be removed with the crankshaft in the engine if desired.

Tighten flywheel bolts evenly and diametrically to torque value given in the SPECIFICATIONS.

Disassembly and Assembly

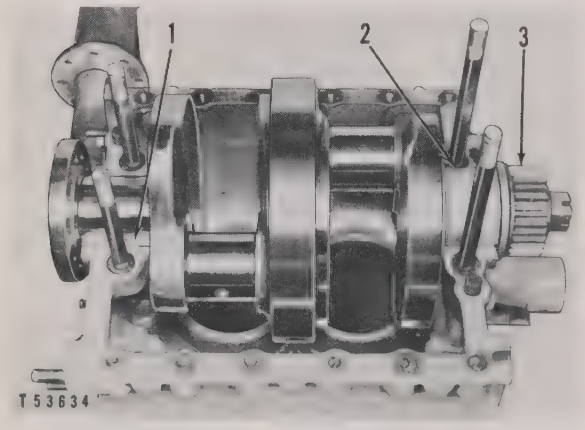
1. Press, cut or burn ring gear from flywheel.
2. Clean the ring gear and flywheel and remove all burrs.
3. Heat ring gear to a temperature not to exceed 600° F., and install on flywheel.

NOTE

Make certain the double chamfered portion of teeth on ring gear is to rear of flywheel.

MAIN BEARINGS

This engine has two main bearings **(1)** and **(2)**. Rear main bearing **(1)** is a split-type consisting of two halves, upper and lower. Front main bearing **(2)** is a one-piece, flange type and takes the thrust of the crankshaft. The front main bearing can be removed only after the crankshaft has been removed from the engine and gear **(3)** has been removed.



MAIN BEARINGS
1–Rear main bearing. 2–Front main bearing. 3–Crankshaft gear.

See the SPECIFICATIONS, for permissible bearing clearance.

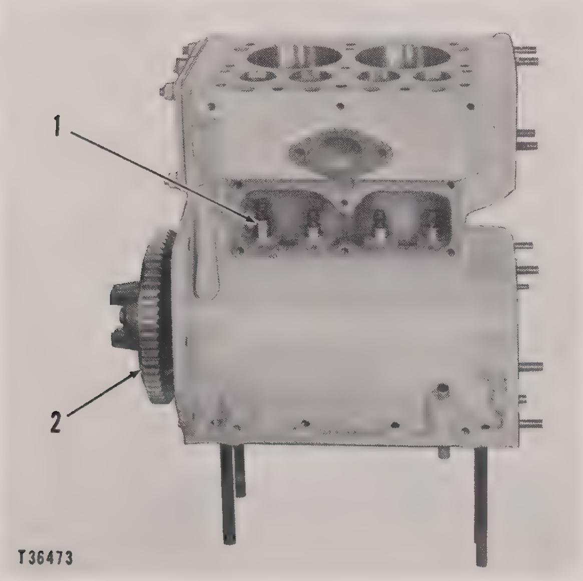
Camshaft

The camshaft can be removed with the camshaft gear in place on the shaft. There are no removable bearings for the camshaft. A precision machined bore in the block provides a bearing surface for the camshaft.

CAMSHAFT REMOVAL AT TIME OF RECONDITIONING

If the camshaft is to be removed at the time of reconditioning the engine, it can be done in the following manner:

1. Remove the head. See the topic, CYLINDER HEAD REMOVAL AND INSTALLATION.



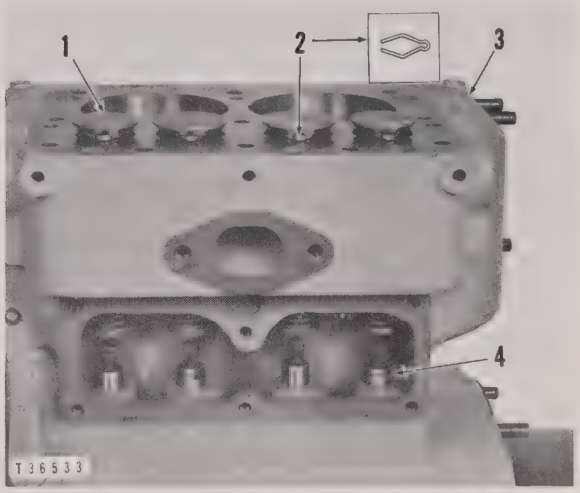
REMOVAL AT TIME OF RECONDITIONING
1–Lifter assembly. 2–Camshaft gear.

2. Remove the timing gear housing. See the topic, TIMING GEAR HOUSING REMOVAL.
3. Remove the valves, see the topic, VALVE MECHANISM REMOVAL.
4. After the valves have been removed, push the lifter assemblies **(1)** to the top of their stroke.
5. Remove the camshaft and camshaft gear **(2)**.

CAMSHAFT REMOVAL SEPARATELY

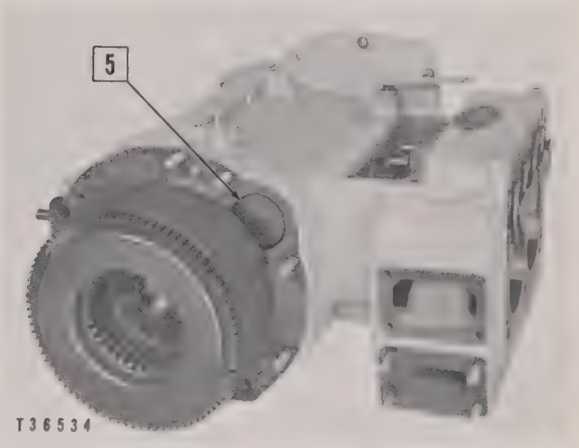
If the camshaft is to be removed at some other time rather than at the time of reconditioning, it can be done in this manner:

1. Remove the head and the timing gear housing as described in the covering topics. The valves need not be removed to remove the camshaft from the cylinder block.
2. Lay the engine on its side with the valve inspection opening up and remove the valve inspection cover.
3. Compress each spring assembly until each valve is at the top of its stroke.



CAMSHAFT REMOVAL SEPARATELY
1–Valve. 2–Large cotter pin. 3–Cylinder block.
4–Lifter assembly.

4. Bend and insert a large cotter pin **(2)** between the valve face and the top of the cylinder block **(3)** where the valve seats. This will keep the valve **(1)** open at the top of its stroke.



PREPARING TO REMOVE CAMSHAFT

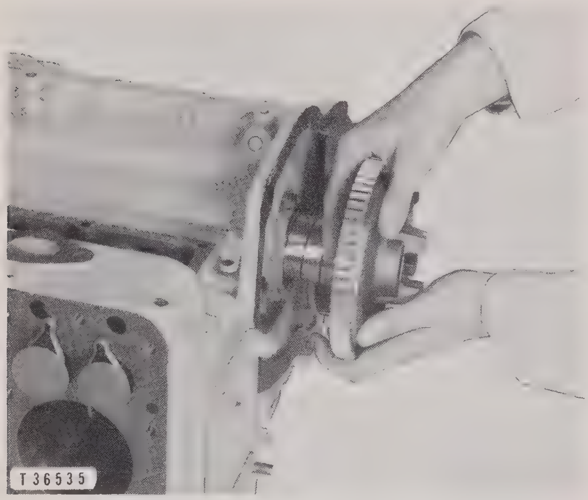
☐ **Remove**

5–Thrust washer.

5. Push the lifter assemblies **(4)** to the top of their stroke.
6. Remove the camshaft and camshaft gear.

CAUTION

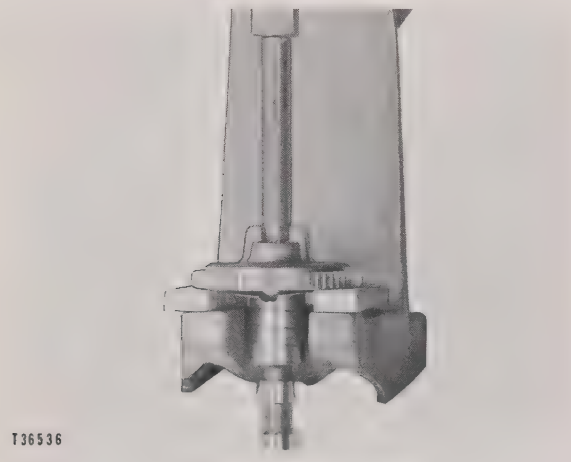
Care should be taken not to damage the camshaft bearing bores when removing and installing the camshaft.



PULLING CAMSHAFT FROM CYLINDER BLOCK

CAMSHAFT GEAR REMOVAL AND INSTALLATION

Remove the bolt, lock and washer from the camshaft gear and press the camshaft from the gear supported on wooden blocks as shown.



CAMSHAFT GEAR REMOVAL

CAUTION

Care should be taken not to damage the governor driver when pressing the camshaft from the camshaft gear.

When installing the camshaft and gear, be sure the timing mark "C" on the camshaft gear is aligned with the timing mark "C" on the crankshaft gear.

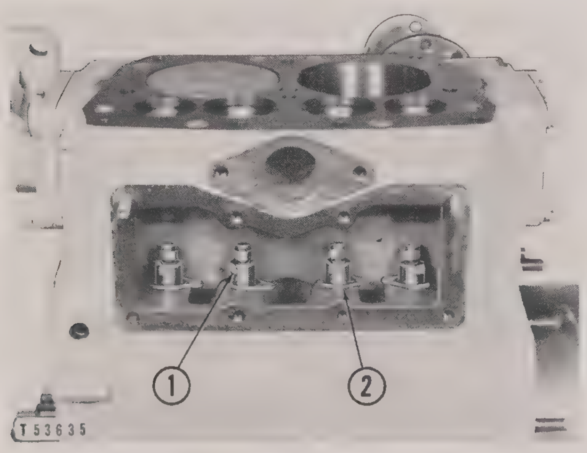
Camshaft

There are no removable bearings for the camshaft. A precision machined bore in the block provides a bearing surface for the camshaft.

CAMSHAFT REMOVAL AT TIME OF RECONDITIONING

If the camshaft is to be removed at the time of engine reconditioning, it can be removed in the following manner:

1. Remove the transmission from the engine. See covering topic.
2. Remove the head. See the topic, CYLINDER HEAD REMOVAL AND INSTALLATION.
3. Remove the timing gear housing and governor. See the topics, TIMING GEAR HOUSING and GOVERNOR.
4. Remove the valves. See the topic, VALVE MECHANISM REMOVAL.



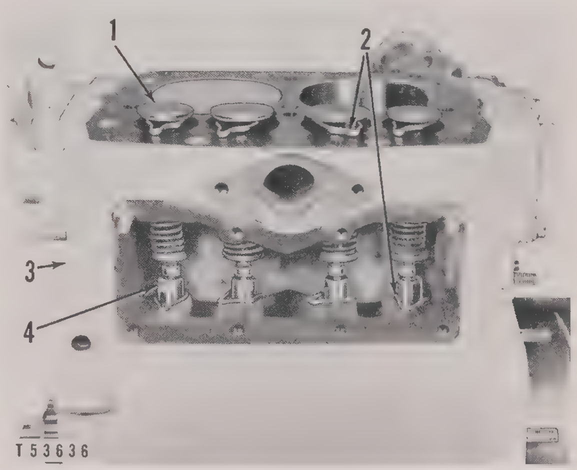
REMOVAL AT TIME OF RECONDITIONING
1–Lifter assembly. 2–Cotter pin.

5. After the valves have been removed, hold the lifters **(1)** at the top of their stroke with cotter pins **(2)** as shown.
6. Remove the camshaft as described in the following topic.

CAMSHAFT REMOVAL SEPARATELY

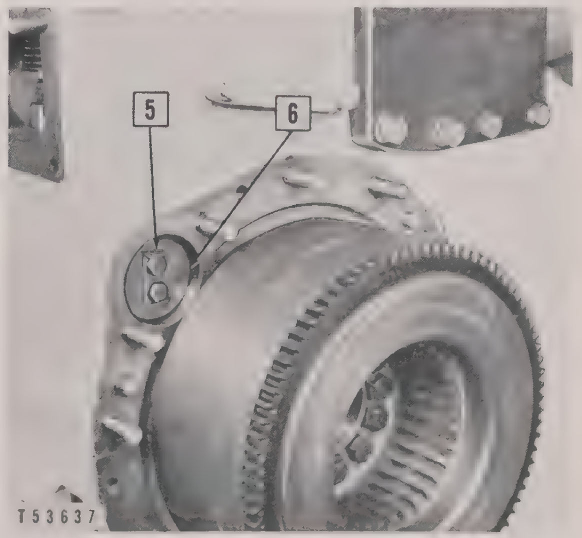
If the camshaft is to be removed at some time other than that of the time of engine reconditioning, it can be removed in the following manner:

1. Remove the transmission from the engine. See the covering topic.
2. Remove the head, timing gear housing, and governor as described in the covering topics. The valves need not be removed to remove the camshaft from the cylinder block.
3. Remove the valve inspection cover and compress each spring assembly until each valve is at the top of its stroke.



CAMSHAFT REMOVAL SEPARATELY
1–Valve. 2–Cotter pin. 3–Block. 4–Lifter assembly.

4. Bend and insert a large cotter pin **(2)** between the valve head and the top of the cylinder block **(3)** where the valve seats. This will keep the valve **(1)** open at the top of its stroke.
5. Hold the lifter assemblies **(4)** at the top of their stroke with cotter pins **(2)**.

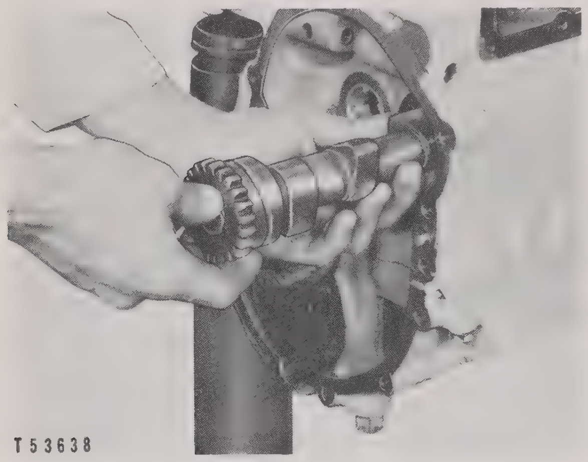


PREPARING TO REMOVE CAMSHAFT

☐ **Remove**

5–Lock and bolts. 6–Thrust washer.

6. Remove the camshaft and gear as shown.



T53638

REMOVING CAMSHAFT

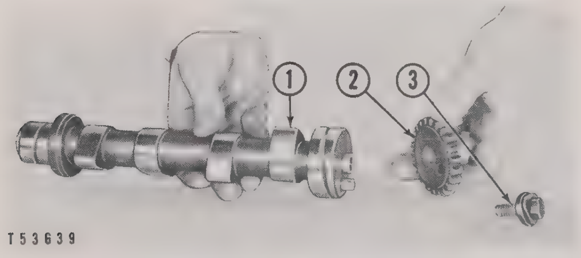
CAUTION

Care should be taken not to damage the camshaft bearing bores when removing and installing the camshaft.

7. See the topic, GOVERNOR REMOVAL AND INSTALLATION, for correct timing of the camshaft and idler gears.

Camshaft Gear Removal and Installation

Remove the bolt, lock and washer **(3)** from the camshaft **(1)** and pull the gear **(2)** from the camshaft.

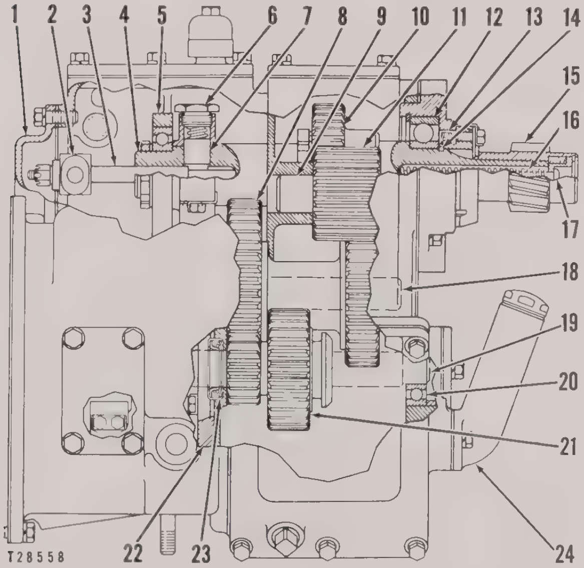


T53639

CAMSHAFT GEAR REMOVAL
1–Camshaft. 2–Camshaft gear. 3–Bolts, lock and washer.

Starting Mechanism

The starting engine transmits its power through a clutch and two speed transmission to a sliding pinion, which is engaged with the diesel engine flywheel gear by means of linkage controlled by a hand lever. The pinion is automatically released by centrifugal force acting on the sleeve assembly when the diesel engine starts. See the topic, STARTER PINION OPERATION. The counterclockwise rotating starting mechanism differs from the clockwise rotating mechanism only in the addition of an idler gear **(11)**. See the topic, IDLER GEAR REMOVAL AND INSTALLATION.



STARTING MECHANISM
1–Release shaft cover. 2–Yoke. 3–Pinion release shaft. 4–Starter pinion shaft. 5–Bearing. 6–Retainer. 7–Sleeve. 8–Cluster gear assembly. 9–Idler gear shaft. 10–Starter engine gear. 11–Idler gear assembly. 12–Bearing. 13–Seal. 14–Ring seal. 15–Starter pinion. 16–Spring. 17–Pinion retaining rod. 18–Cluster gear shaft. 19–Clutch shaft. 20–Bearing. 21–Sliding pinion. 22–Ring. 23–Seal. 24–Oil filler.

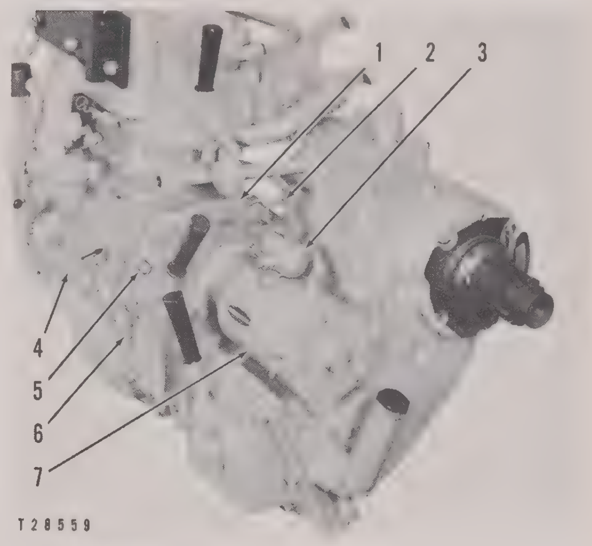
CLUTCH HOUSING REMOVAL AND INSTALLATION

1. Remove the starting engine from the diesel engine. See the topic, STARTING ENGINE REMOVAL.

NOTE

Before removing the clutch housing **(1)** from from the engine, engage the clutch. This will keep the inner and outer discs aligned to facilitate installation.

2. Loosen the wires **(2)** from the magnetic switch **(3)** and remove the starting motor **(7)**.
3. Remove the bolts **(6)** and nuts **(5)** that secure the clutch and transmission housing **(1)** to the starting engine **(4)**.

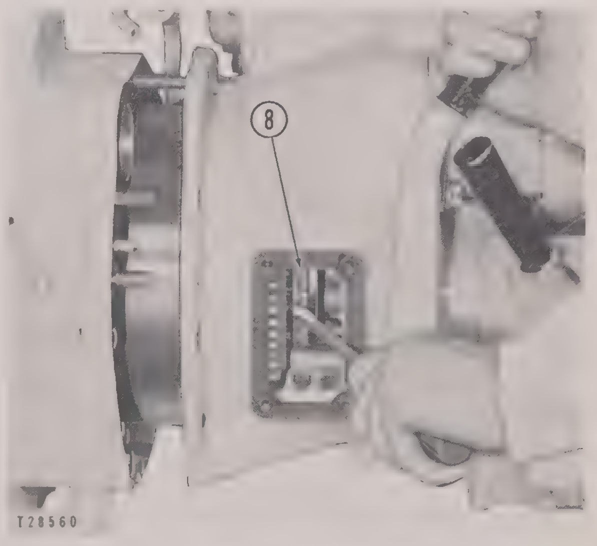


PREPARING TO REMOVE STARTING MECHANISM
1–Clutch and transmission housing. 2–Wiring. 3–Magnetic switch. 4–Starting engine. 5–Nut. 6–Bolt. 7–Starting motor.

4. Pull the housing off the starting engine, being careful not to damage the stud threads.
5. Inspect all parts for damage and install in the reverse order of removal.

NOTE

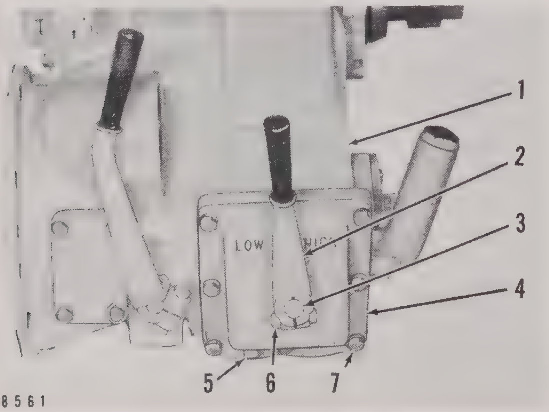
For alignment of the clutch plates **(8)** with the starting engine flywheel serrations, see the illustration.



ALIGNING CLUTCH PLATES
8–Clutch plates.

TRANSMISSION SHIFT LEVER AND COVER REMOVAL AND DISASSEMBLY

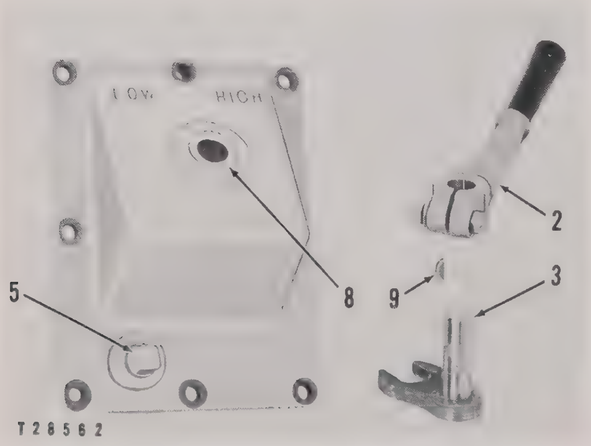
1. Remove the transmission drain plug **(5)** and drain the lubricant from the housing.
2. Remove the bolts **(7)** holding the cover **(4)** to the housing **(1)** and remove the cover and lever assembly.
3. Loosen the locknut **(6)** holding the gear shift lever **(2)** to the shaft **(3)** and remove the lever.



T28561

PREPARING TO REMOVE SHIFT LEVER AND COVER
1–Housing. 2–Shift lever. 3–Shaft. 4–Cover. 5–Drain plug. 6–Nut. 7–Bolt.

4. Remove the key **(9)** from the shaft and pull the shaft from the cover.
5. If the seal **(8)** requires replacement, install it with the lip toward the outside of the cover.



T28562

LEVER AND SHAFT REMOVAL
2–Lever. 3–Shaft. 5–Drain plug. 8–Oil seal. 9–Key.

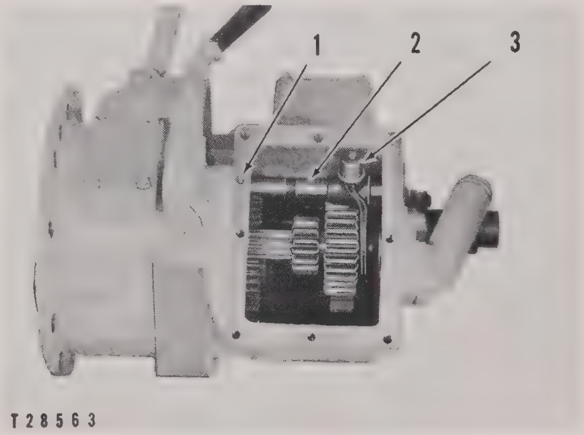
6. Inspect all parts and assemble in the reverse order of disassembly.

TRANSMISSION SHIFTING MECHANISM DISASSEMBLY AND ASSEMBLY

1. Remove the shift lever and cover. See the covering topic.
2. Remove the pin **(1)** holding the shaft **(2)** in the housing.
3. Using a drift punch, through the housing, drive against the forward expansion plug **(4)** forcing it, the shaft **(2)** and the rear expansion plug **(7)** out of the housing.

CAUTION

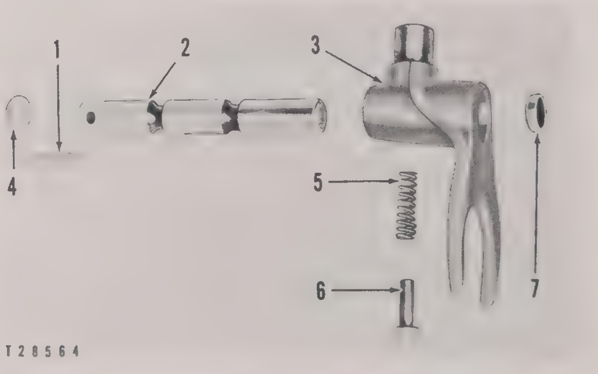
Be sure to remove the forward expansion plug, which will have dropped into the housing from the transmission before reassembly. This also holds true for the shifter fork plunger **(6)** and spring **(5)** which will be expelled into the housing as soon as the plunger clears the end of the shaft.



T28563

PREPARING TO REMOVE SHIFTING MECHANISM
1–Pin. 2–Shaft. 3–Shifter fork.

4. After the shaft is about one-half of the way out of the housing, slide the shifter fork **(3)** from the shaft and complete the removal of the shaft.



T28564

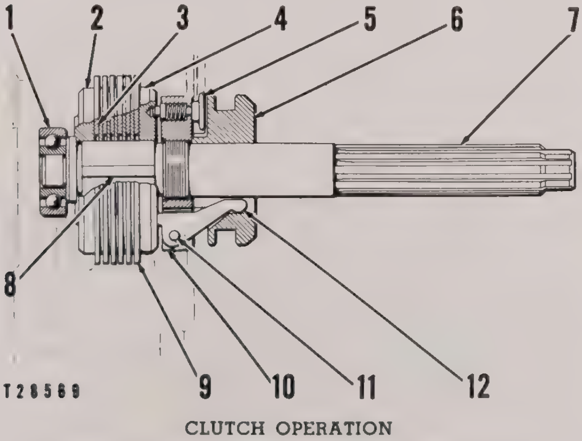
TRANSMISSION SHIFTING MECHANISM
1–Pin. 2–Shaft. 3–Shifter fork. 4–Forward expansion plug. 5–Spring. 6–Plunger. 7–Rear expansion plug.

5. Inspect all parts for damage and assemble in the reverse order of disassembly.

CLUTCH

Operation

The clutch is of the oil type, with five inner discs **(3)** and six outer discs **(9)**. The bearing **(1)** pilots the clutch in the starting engine flywheel. Teeth on the inside of the flywheel mate with the teeth on the outer, or driving discs **(9)**. The inner, or driven discs **(3)** rotate the shaft **(7)** by means of the keys **(8)**. The front and rear pressure plates **(2)** and **(4)** are also keyed to the shaft. The clutch is engaged and disengaged by a lever and yoke which slide the collar **(6)** on the shaft. As the collar moves to the rear, the dogs **(12)** rotate about the pins **(11)**, releasing pressure on the plate **(4)**, and disengaging the clutch. The braking cone, which is the chamfered edge of the collar **(6)**, engages a mating ring on the clutch housing to stop rotation of the shaft, at which time the starter pinion can be engaged with the flywheel ring gear of the diesel engine. Moving the collar forward forces the ends of the dogs **(12)** inward, engaging the clutch. The spider **(10)** is threaded to the shaft **(7)**, providing for clutch adjustment. The plunger **(5)** seats in one of the series of holes in the rear face of the plate **(4)** to lock the spider after adjustment.



CLUTCH OPERATION
1–Bearing. 2–Plate. 3–Disc. 4–Plate. 5–Plunger. 6–Collar. 7–Shaft. 8–Key. 9–Disc. 10–Spider. 11–Pin. 12–Dog.

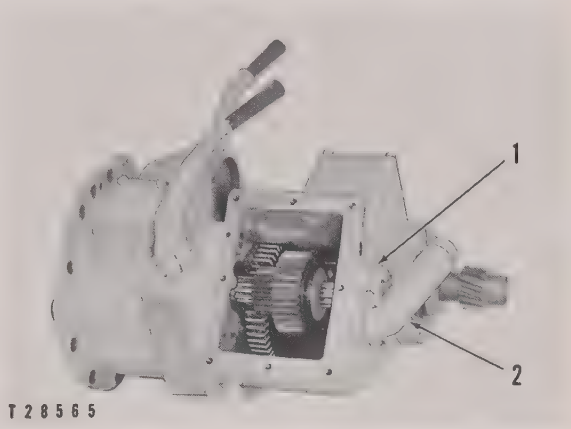
Removal and Installation

1. Remove the starting engine clutch housing and the transmission shifting mechanism as outlined under those topics.

2. Remove the clutch shaft bearing cover **(1)** and filler **(2)**.

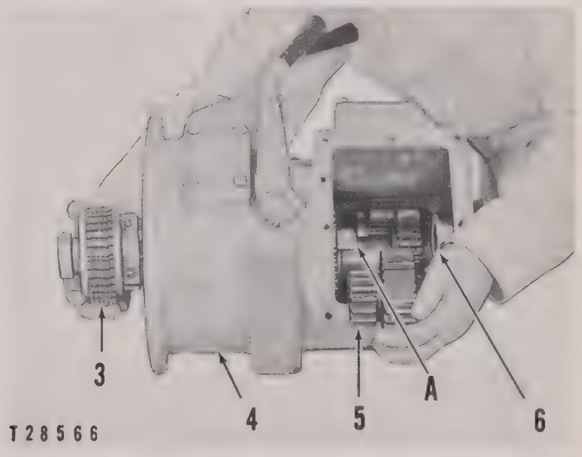
3. Drive the clutch and shaft assembly **(3)** by using a soft drift at **(A)**, partially from the housing **(4)**.

4. Remove the bearing **(6)** from the shaft.



PREPARING TO REMOVE CLUTCH AND SHAFT
1–Clutch shaft bearing cover. 2–Filler.

5. Holding the sliding gear **(5)** so it cannot drop and damage the teeth of the gear, remove the clutch and shaft assembly from the housing.



REMOVING CLUTCH SHAFT AND SLIDING GEAR
A–Point of contact for driving shaft from housing. 3–Clutch and shaft assembly. 4–Housing. 5–Sliding gear. 6–Bearing.

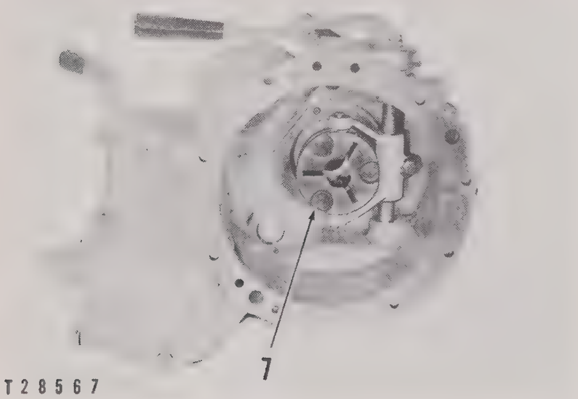
6. Remove the clutch control collar **(7)** from the yoke.

NOTE

Inspect the oil seal **(12)** and bearing **(6)** and replace if necessary. Heat the bearing in hot oil and install in the reverse order of removal.

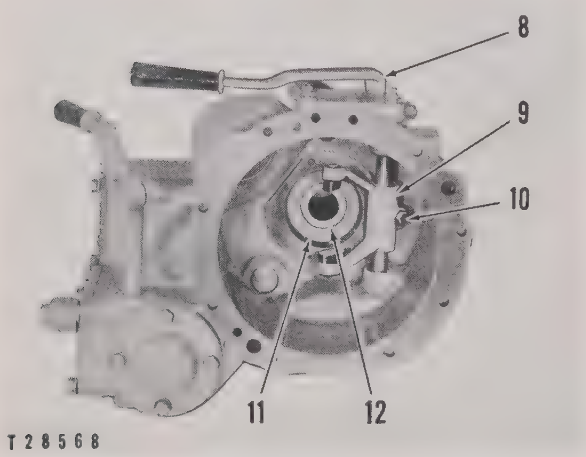
7. Loosen the clamping bolt **(10)**, slide the clutch yoke **(9)** to one side and remove the key from the shaft.

8. Pull the shaft and lever assembly from the housing and remove the yoke.



REMOVING CLUTCH CONTROL COLLAR
7–Collar.

9. Replace any damaged parts and install in the reverse order of removal.



PREPARING TO REMOVE CLUTCH LEVER AND YOKE
8–Lever. 9–Yoke. 10–Bolt. 11–Ring. 12–Oil seal.

NOTE

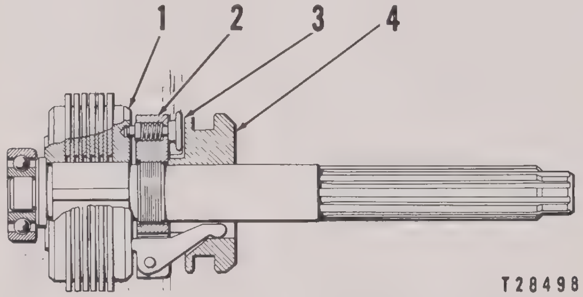
Loosen the bolts which hold the ring **(11)** to the housing before installing the clutch assembly. See the topic, ADJUSTMENT, for the proper time to tighten the bolts.

Adjustment

The clutch should be adjusted after the clutch has been installed, and the clutch housing installed to the cylinder block and oil pan.

Pull the plunger **(3)** until it clears the hole in the plate **(1)**, and rotate the spider assembly **(2)** clockwise to tighten the clutch, or counterclockwise to loosen. Release the plunger into the nearest hole to lock the adjustment. When properly adjusted, it should require a distinct snapover to engage and disengage the clutch.

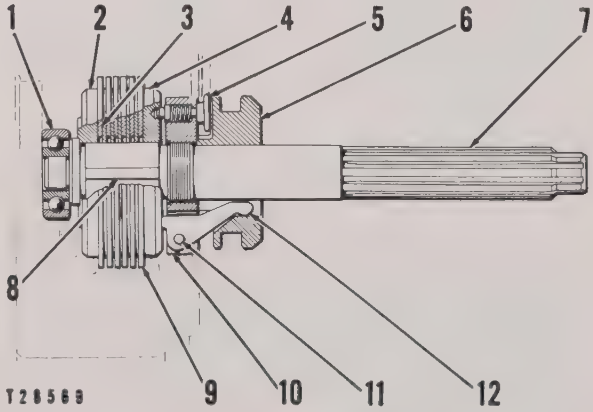
Engage the clutch brake and tighten the two bolts holding the braking ring to the clutch housing. This will center the ring with relation to the chamfered surface of the collar **(4)**.



CLUTCH ADJUSTMENT
1–Plate. 2–Spider assembly. 3–Plunger. 4–Collar.

Disassembly and Assembly

1. Disengage the clutch by removing the throw-out collar **(6)** from the shaft **(7)**.
2. Pull the plunger **(5)** and turn the spider assembly **(10)** counterclockwise to remove it from the shaft.
3. The dogs **(12)** can be removed by removing the pins **(11)**.



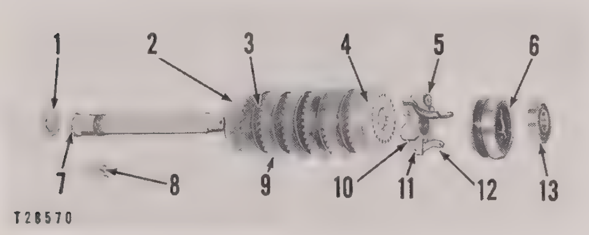
CLUTCH DISASSEMBLY
1–Bearing. 2–Plate. 3–Inner disc. 4–Plate. 5–Plunger. 6–Collar. 7–Shaft. 8–Key. 9–Outer disc. 10–Spider assembly. 11–Pin. 12–Dog.

4. Remove the plate **(4)**.
5. Remove the inner discs **(3)** and outer discs **(9)**.
6. Remove the plate **(2)** and the keys **(8)** from the shaft **(7)**.

7. Remove the bearing **(1)** from the shaft.
8. Assemble in the reverse order of disassembly.

NOTE

The bearing **(13)** must be installed on the shaft after the clutch assembly is installed in the housing. See the topic, CLUTCH REMOVAL AND INSTALLATION.

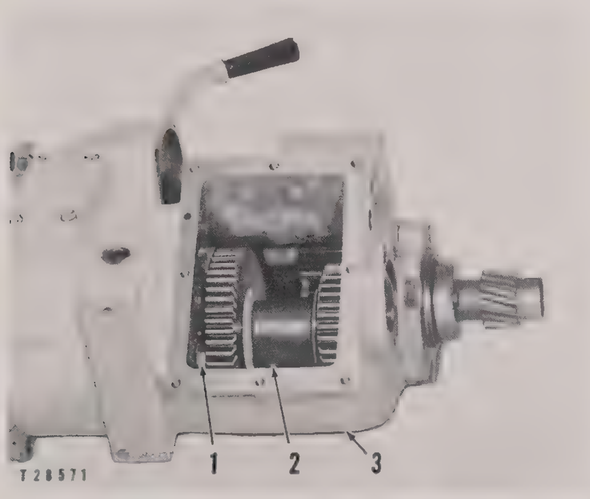


CLUTCH - EXPLODED VIEW
1–Bearing. 2–Plate. 3–Inner disc. 4–Plate. 5–Plunger. 6–Collar. 7–Shaft. 8–Key. 9–Outer disc. 10–Spider assembly. 11–Pin. 12–Dog. 13–Bearing.

CLUSTER GEAR

Removal and Installation

1. Remove the clutch assembly. See the topic, CLUTCH REMOVAL AND INSTALLATION.
2. Remove the bolts **(1)** securing the clutch brake ring to the housing **(3)**.

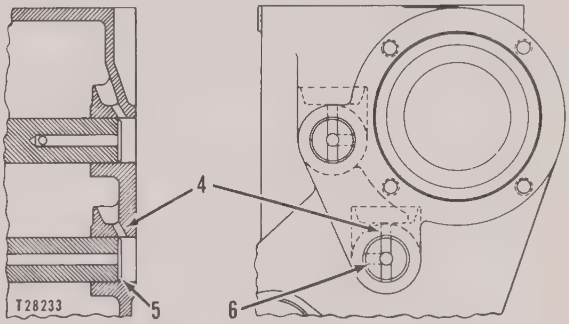


PREPARING TO REMOVE THE CLUSTER GEAR
1–Bolt. 2–Cluster gear. 3–Housing.

3. Using a drift punch through the housing, drive against the cluster gear shaft forcing the expansion plug and the shaft out of the housing.
4. Remove the cluster gear assembly **(2)** and check the sleeve bearings for wear or damage.
5. Install in the reverse order of removal, using new expansion plugs.

NOTE

An oil passage is drilled half way through the shaft **(5)** connecting with the oil passage **(6)** to the outside of the shaft, providing lubrication to the cluster gear bearings. When installing, make certain that the slotted end of the shaft **(5)** aligns with the oil passage **(4)** in the housing, and that the oil passage **(6)** is facing away from the diesel engine. The end of the shaft should be 7/16″ from the outer surface of the housing.



SECTION - REAR VIEW
INSTALLING CLUSTER GEAR SHAFT
4–Oil passage. 5–Shaft. 6–Oil passage.

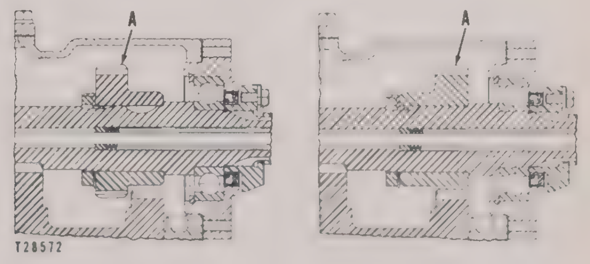
IDLER GEAR

Removal and Installation

1. Remove the starter pinion assembly **(3)**. See the topic, STARTER PINION REMOVAL AND INSTALLATION.

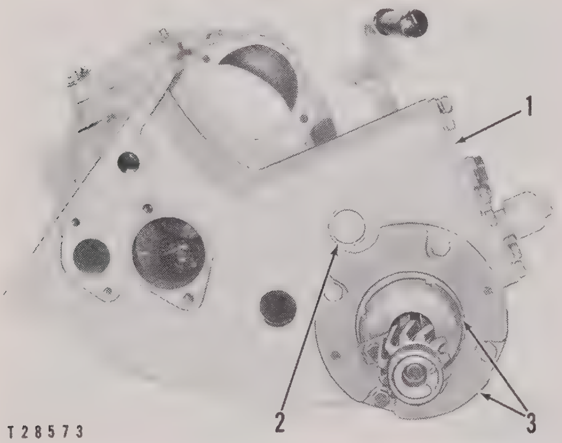
NOTE

The idler gear is used only in the starting mechanism for diesel engines that rotate in a counterclockwise direction. In the clockwise rotation starting mechanism, the starter gear **(A)** is reversed on the pinion shaft and in constant mesh with the small gear of the cluster gear assembly. See the illustration.



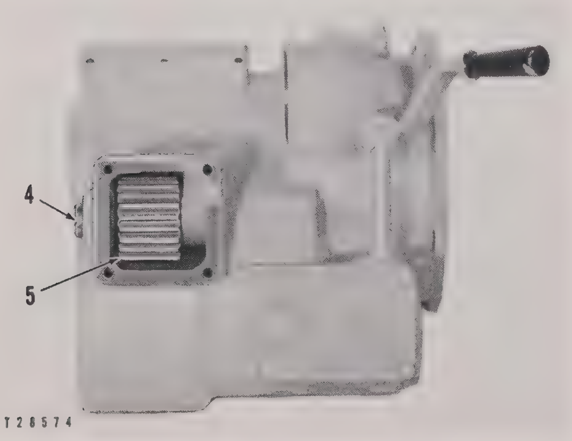
Counterclockwise **Clockwise**
STARTER PINION ROTATION
A–Starter gear.

2. Remove the expansion plug **(2)** from the housing.



PREPARING TO REMOVE THE IDLER GEAR
1–Cover. 2–Plug. 3–Starter pinion assembly.

3. Remove the idler gear cover **(1)**.
4. Using a 3/8" - 16 (NC) bolt **(7)** 1¾" long, a 1¾" flat washer **(6)** and a spacer **(8)** that will fit over the diameter of the shaft **(4)**, pull the shaft from the gear **(5)** and housing as illustrated.

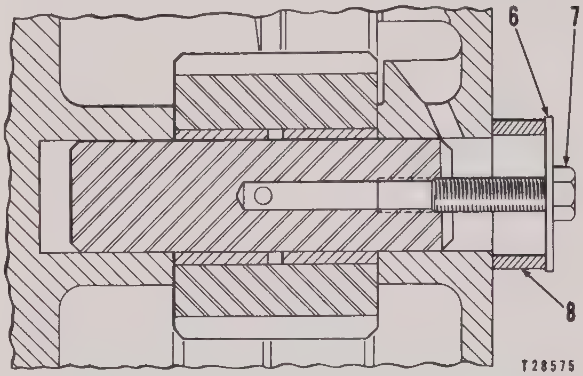


REMOVING IDLER GEAR AND SHAFT
4–Shaft. 5–Gear.

NOTE

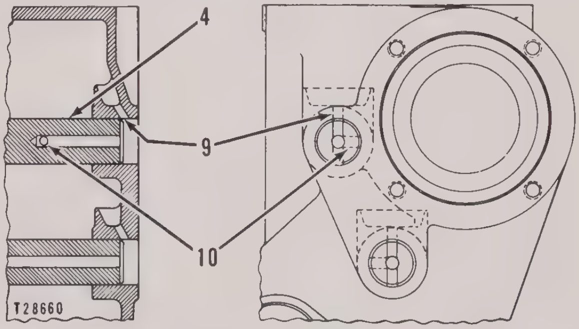
An oil passage is drilled half way through the shaft **(4)**, connecting with the oil passage **(10)** to the outside of the shaft, providing lubrication to the idler gear bearings. When installing, make certain that the slotted end of the shaft **(4)** aligns with the oil passage **(9)** in the housing, and that the oil passage **(10)** is facing the diesel engine. The end of the shaft should be 7/16" from the outer surface of the housing.

5. Remove the idler gear assembly and check the sleeve bearings for wear or damage.



PULLING THE SHAFT FROM THE GEAR
6–Washer. 7–Bolt. 8–Spacer.

6. Install in the reverse order of removal, using a new expansion plug.



SECTION - REAR VIEW
INSTALLING IDLER GEAR SHAFT
4–Shaft. 9–Oil passage. 10–Oil passage.

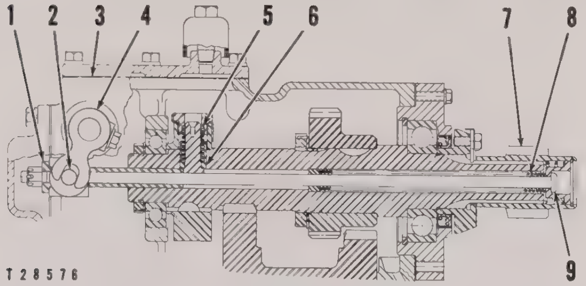
STARTER PINION

Operation

To engage the pinion **(7)**, the lever **(4)** must be moved toward the front of the housing **(3)**. The lever contacts the yoke **(2)** on the release shaft **(1)**, this in turn pulls the retaining rod **(9)** and pinion forward, compressing the spring **(8)**.

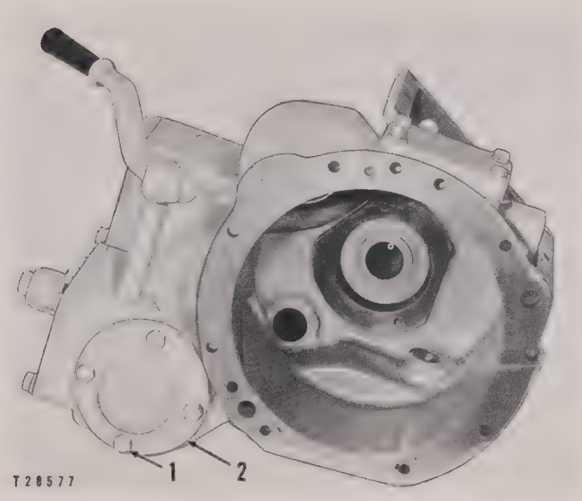
The release shaft must be pulled into the housing far enough to permit the sleeve assembly **(6)** to snap into place blocking the shaft **(1)** from returning to the disengaged position. The pinion is then engaged with the ring gear of the diesel engine flywheel.

The pressure of the spring **(5)** being applied against the sleeve **(6)**, prevents the shaft from returning to the disengaged position until centrifugal force overcomes the 29 to 35 pound spring pressure, forces the sleeve outward and allows the pressure of the spring **(8)** to return the pinion to the disengaged position.



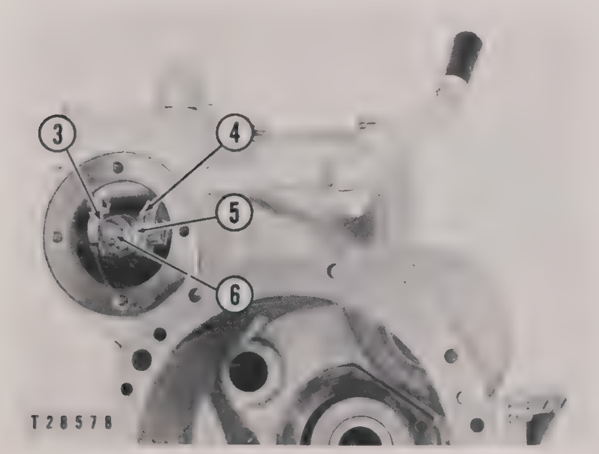
STARTER PINION OPERATION (ENGAGED POSITION)
1–Pinion release shaft. 2–Yoke. 3–Housing. 4–Lever. 5–Spring. 6–Sleeve. 7–Pinion. 8–Spring. 9–Pinion retaining rod.

Removal and Installation



PREPARING TO REMOVE THE STARTER PINION
1–Bolt. 2–Cover.

1. Remove the starter engine clutch. See the topic, CLUTCH REMOVAL AND INSTALLATION.



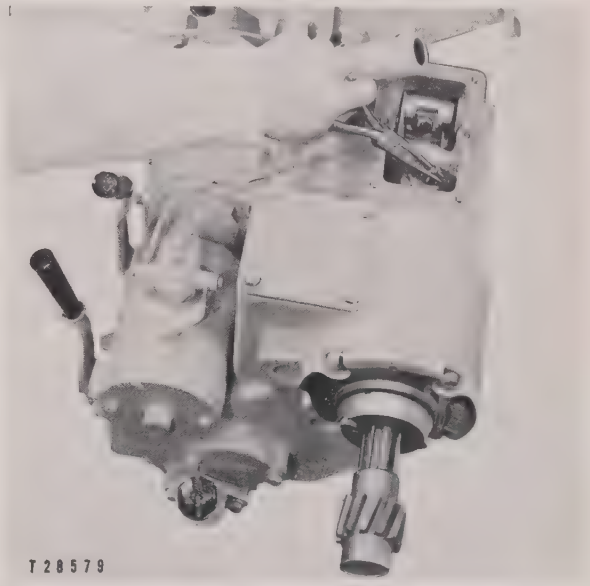
REMOVING STARTER PINION YOKE AND SHAFT
3–Nut. 4–Yoke. 5–Shaft. 6–Rod.

2. Remove the cluster gear. See the topic, CLUSTER GEAR REMOVAL AND INSTALLATION.
3. Remove the bolts **(1)** and the cover **(2)**.
4. Remove the cotter pin and the adjusting nut **(3)** and slide the shaft **(5)** and the yoke **(4)** from the rod **(6)**.

CAUTION

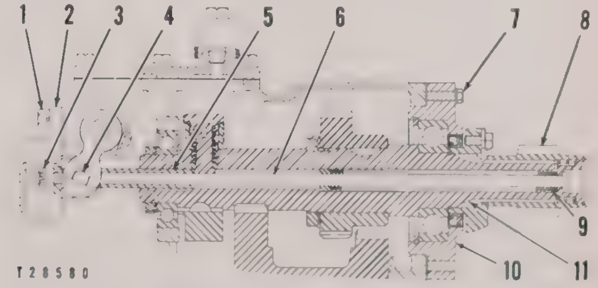
When removing the nut **(3)** from the end of the rod **(6)**, make certain that the starter pinion is in the disengaged position so that the tension on the spring **(9)** will not eject the rod forcefully from the pinion **(8)**.

To disengage the starter pinion manually, insert a No. 8 - 32 (NC) stove bolt into the carrier retainer and with a pair of pliers as illustrated, pull up on the bolt.



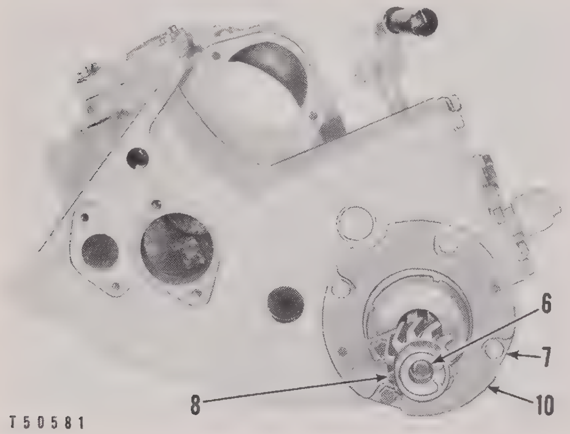
DISENGAGING THE STARTER PINION MANUALLY

5. Slide the pinion **(8)** and rod **(6)** as an assembly from the shaft **(11)**.



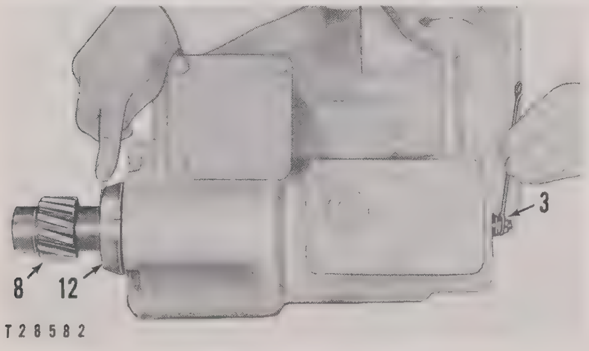
STARTER PINION AND SHAFT
1–Bolt. 2–Cover. 3–Nut. 4–Yoke. 5–Shaft. 6–Rod. 7–Bolt. 8–Pinion. 9–Spring. 10–Cover. 11–Shaft.

6. Remove the bolts **(7)**, the cover **(10)** and slide the starter pinion shaft assembly out of the transmission housing.



STARTER PINION REMOVAL
6–Rod. 7–Bolt. 8–Pinion. 10–Cover.

7. Install in the reverse order of removal, replacing all worn or damaged parts.
8. To adjust the pinion clearance, place the pinion in the engaged position. Turn the adjusting nut **(3)** up snug against the face of the sleeve, then back the nut off until a .010" to .030" thickness gauge can be inserted between the head of the pinion **(8)** and the face of the nut **(12)** as illustrated.



PINION ADJUSTMENT
3–Nut. 8–Pinion. 12–Nut.

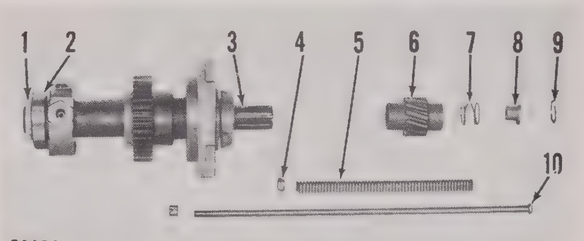
Disassembly and Assembly

1. Slide the pinion **(6)**, the lock ring **(9)**, the retaining washer **(8)**, the spring **(7)** and the rod **(10)** from the starter pinion shaft **(3)** as an assembly.

NOTE

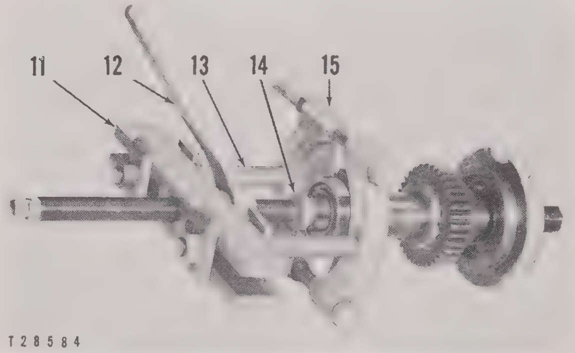
If required, the washer, spring and rod can be removed from the pinion assembly by removing lock ring **(9)**.

2. Remove the spring **(5)** and the guide **(4)** from the shaft.



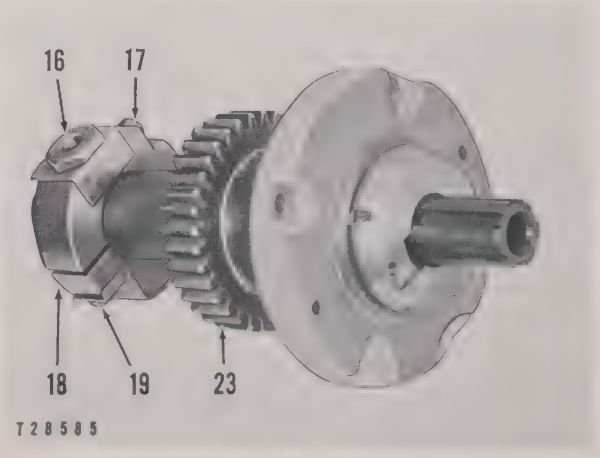
REMOVING PINION GEAR AND ROD
1–Nut. 2–Bearing. 3–Shaft. 4–Guide. 5–Spring. 6–Pinion. 7–Spring. 8–Washer. 9–Lock. 10–Rod.

3. Remove the lock and the nut **(1)** which holds the bearing **(2)** to the outer end of the shaft.



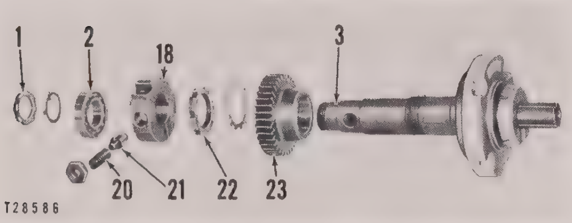
REMOVING THE CARRIER BEARING
11–Puller. 12–Wrench. 13–Legs. 14–Step plate. 15–Puller.

4. Using an 8B7551 Bearing Puller **(15)**, a 1H3107 Push-puller **(11)**, two 8B7550 Legs **(13)**, an 8B7560 Step Plate **(14)** and an 8B7562 Box Wrench **(12)**, remove the carrier bearing **(2)** from the shaft.



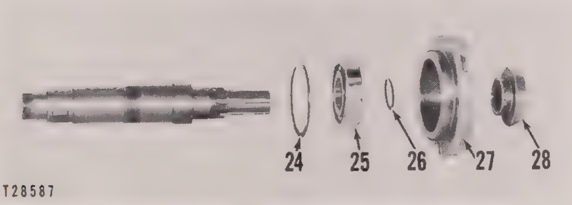
PREPARING TO REMOVE THE CARRIER
16–Retainer. 17–Bolt. 18–Carrier. 19–Bolt. 23–Starter gear.

5. Remove the lock and bolt **(17)** which holds the sleeve assembly inside the carrier **(18)**.
6. Remove the lock, the retainer **(16)**, the spring **(20)** and the sleeve assembly **(21)**.



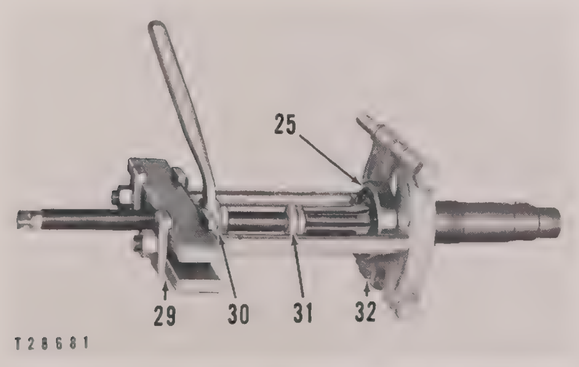
REMOVING CARRIER AND STARTER GEAR
1–Nut. 2–Bearing. 3–Shaft. 18–Carrier. 20–Spring. 21–Sleeve assembly. 22–Nut. 23–Gear.

7. Remove the lock and clamping bolt **(19)** and tap the carrier **(18)** from the shaft and remove the key.
8. Remove the starter gear lock and nut **(22)** and tap the gear **(23)** from the shaft **(3)**.



REMOVING THE COVER FROM THE SHAFT
24–Lock. 25–Bearing. 26–Ring seal. 27–Cover. 28–Nut.

9. Remove the cover lock and bolt and the nut **(28)** from the shaft.



REMOVING THE CARRIER BEARING
25–Bearing. 29–Puller. 30–Wrench. 31–Step plate. 32–Puller.

10. Remove the lock **(24)** from the inside of the bearing cover and remove the cover **(27)**.
11. Inspect the oil seal inside the bearing cover and replace if worn or damaged.
12. Remove the ring seal **(26)** from the shaft.
13. Using an 8B7548 Bearing Puller **(32)**, a 1H3107 Push Puller **(29)**, an 8B7560 Step Plate **(31)** and an 8B7562 Box Wrench **(30)**, remove the cover bearing **(25)** from the shaft.
14. Inspect all parts and replace if worn or damaged. Install in the reverse order of removal.

HC652513

Service Manual
Section Index Tab
FORM 34261-12

ATTACHMENTS

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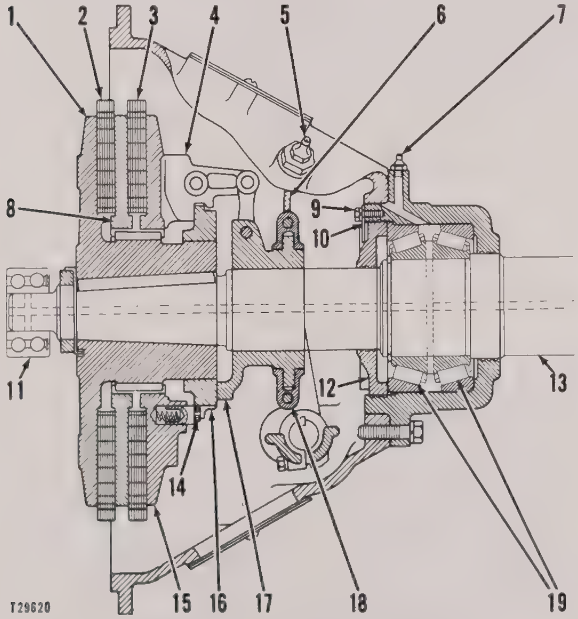
Front Power Take-off

OPERATION AND LUBRICATION

The clutch used on the front power take-off is the dry, snap-over-center type. It is driven by a coupling that bolts to the crankshaft. The coupling transmits power from the crankshaft to the driving plates **(2)** and **(3)**. These plates and coupling turn when the engine is running. The clutch is engaged by moving the sleeve **(17)** forward, which actuates four levers **(4)**. These levers move the driven plate **(15)** forward, compressing the driving plates **(2)** and **(3)** between the center driven plate **(8)** and the plate **(1)**. The power is then transmitted to the shaft **(13)** through the driven plates **(8)** and **(15)** which are engaged to the plate **(1)** by means of teeth. The plate **(1)** is keyed to the shaft **(13)**.



OPERATION AND LUBRICATION
1–Plate. 2–Driving plate. 3–Driving plate. 4–Lever. 5–Fitting. 6–Hose. 7–Fitting. 8–Driven plate. 9–Bolt. 10–Lock. 11–Pilot bearing. 12–Retainer. 13–Shaft. 14–Pin. 15–Driven plate. 16–Ring. 17–Sleeve. 18–Collar assembly. 19–Tapered bearings.

The clutch is lubricated through three fittings. The fitting in the exposed end of the shaft lubricates the pilot bearing **(11)** which is located in the coupling and supports the end of the clutch shaft. The fitting **(7)** lubricates the two tapered bearings **(19)** which support the shaft **(13)**. The fitting **(5)** on the housing connects to the hose **(6)** and lubricates the collar assembly **(18)** that actuates the sleeve **(17)**.

The clutch is adjusted by pushing the spring-loaded pin **(14)** in and rotating the adjusting ring **(16)**. Turn the adjusting ring clockwise to tighten the adjustment and counterclockwise to loosen the adjustment.

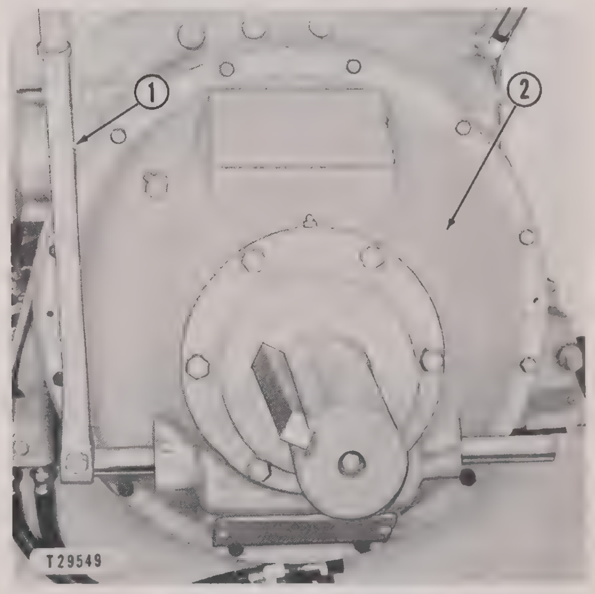
Adjustments to the bearings should be made with no grease in the bearings. Then tighten the bearing retainer **(12)** until the shaft begins to drag when turned by hand. Loosen the retainer two or three notches. The bearing clearance should be adjusted to give .006″-.010″ end clearance as checked with a dial indicator. Lock the retainer in place with the bolt **(9)** and its lock **(10)**.

NOTE

After adjusting the bearings, it is recommended to tap the end of the shaft to break loose any tightness that may result due to the resistance of the pilot bearing when being pressed into the flywheel.

REMOVAL AND INSTALLATION

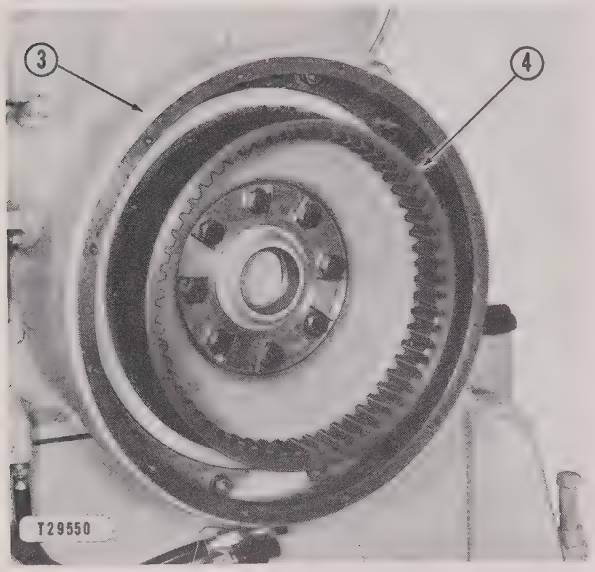
1. Engage the clutch and remove the lever **(1)**. This will prevent the driving plate from slipping out of alignment with the coupling when the clutch is removed.



REMOVING CLUTCH ASSEMBLY
1–Lever. 2–Clutch assembly.

2. Support the clutch assembly **(2)** with a suitable hoist.
3. Remove the clutch housing bolts, insert forcing screws in the holes provided in the housing, and remove the clutch assembly.
4. Remove two bolts on a common centerline that support the couplings **(4)** and install guide pins to support the oil thrower.

5. Remove the remaining bolts and locks and remove the coupling.



REMOVING COUPLING
3–Adapter. 4–Coupling.

6. Inspect the pilot bearing for excessive wear, and replace if necessary by removing it from the clutch shaft.

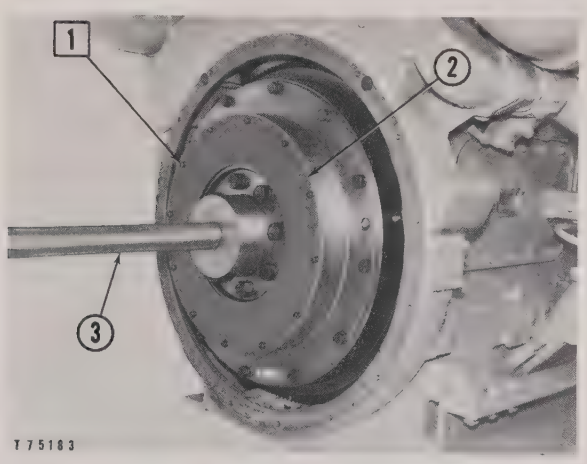
NOTE

Maintain a clearance not greater than 1/16″ between the outer edge of the bearing and the end of the shaft to prevent the end of the shaft from interfering with the coupling.

7. Check the alignment of the driving discs by slipping the coupling over them. If the coupling binds, disengage the clutch, align the discs, and engage the clutch.
8. Complete the installation in reverse order of removal.

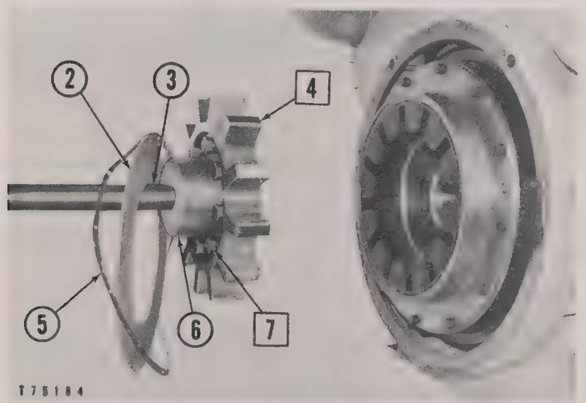
REMOVAL AND DISASSEMBLY

1. Remove the guard from around the coupling.
2. Move plate **(2)** and gasket **(5)** away from the coupling and let them rest on drive shaft **(3)**.



PREPARING TO REMOVE DRIVEN COUPLING
1–Bolts. 2–Plate. 3–Drive shaft.

3. Depending on the installation-set up of the engine and driven equipment, do whatever is necessary to separate shaft **(3)** and driven coupling **(4)** from the engine.

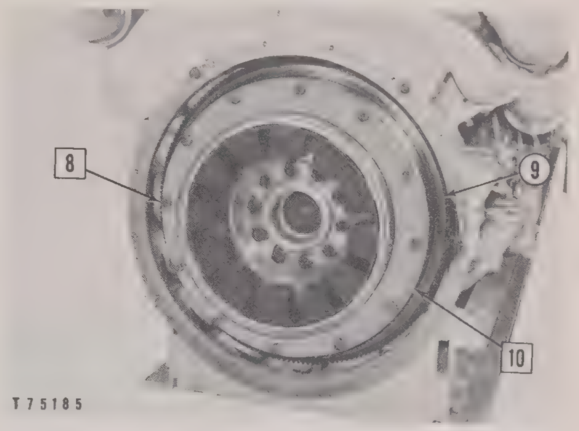


DRIVE SHAFT AND DRIVEN COUPLING REMOVED
2–Plate. 3–Drive shaft. 4–Driven coupling. 5–Gasket. 6–Hub. 7–Bolts.

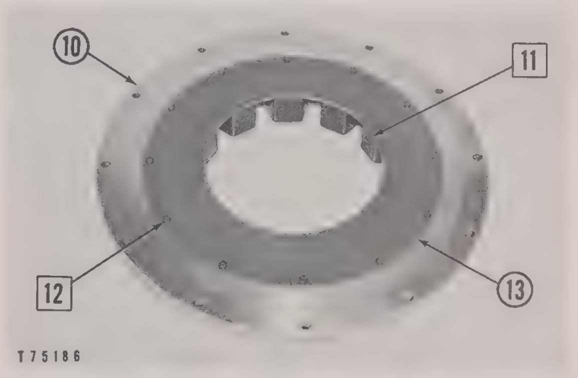
4. Hub **(6)** is a press fit on shaft **(3)** and is secured by a key. Press hub off shaft.
5. Remove the plate and gasket **(13)** from the side of the coupling which faces the flywheel.

NOTE

Plate **(2)** and gasket **(5)** are identical to plate and gasket **(13)**.



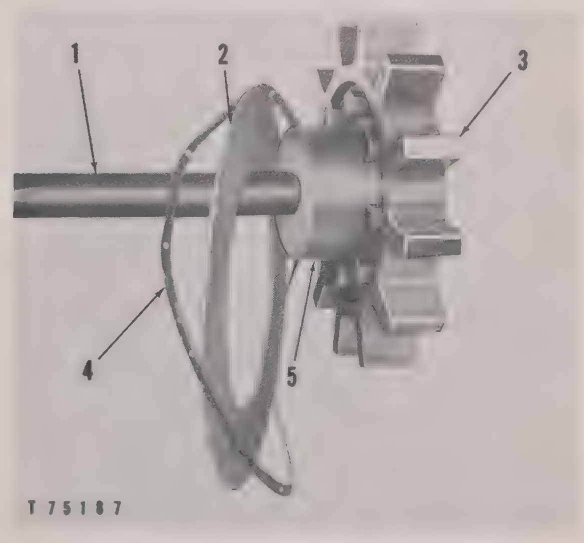
PREPARING TO REMOVE DRIVE COUPLING
8–Bolts. 9–Flywheel. 10–Drive coupling.



PREPARING TO REMOVE BOOT
10–Drive coupling. 11–Boot. 12–Bolts. 13–Plate and gasket.

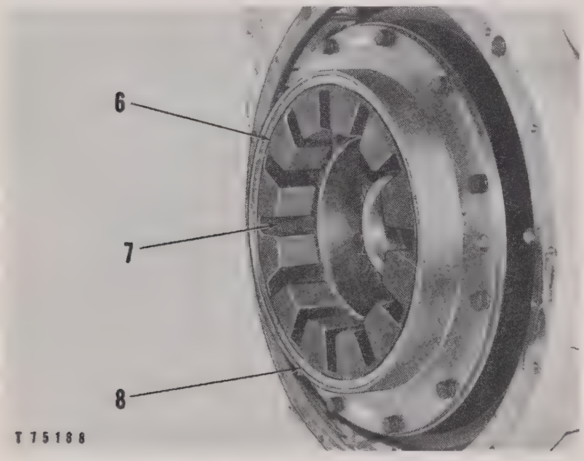
ASSEMBLY AND INSTALLATION

1. Clean all parts thoroughly.



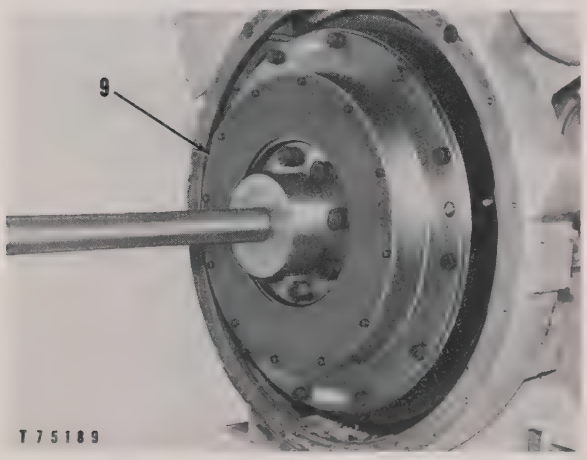
INSTALLING HUB AND DRIVEN COUPLING
1–Drive shaft. 2–Plate. 3–Driven coupling. 4–Gasket. 5–Hub.

2. Install key into keyway of drive shaft **(1)**.
3. Align the key slot in hub **(5)** with the key in the drive shaft and press the hub onto the drive shaft. The hub can be heated to facilitate installation.
4. Place plate **(2)** and gasket **(4)** over hub **(5)** and onto the drive shaft.
5. Install driven coupling **(3)** onto the hub.
6. Install the gasket and plate on the flange side of drive coupling **(8)**.
7. Install coupling **(8)** onto the engine flywheel.
8. Place boot **(6)** over the teeth of drive coupling.



INSTALLING DRIVING COUPLING AND BOOT
6–Boot. 7–Teeth and cavities of boot. 8–Drive coupling.

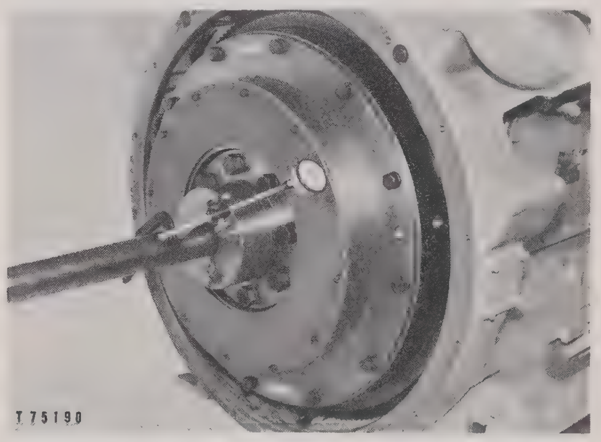
9. Apply some 4L7464 Silicone Grease on the teeth and cavities **(7)** of the boot.
10. Move the engine or the driven equipment, depending upon the installation, until the driven coupling is fully engaged with the drive coupling.
11. Fill the void between boot **(6)** and the driven coupling with silicone grease.
12. Install gasket and plate **(9)**.
13. Make certain the drive coupling is centered between plate **(2)** and **(9)**, so as not to restrict the engine crankshaft end clearance.



INSTALLING GASKET AND PLATE
9–Gasket and plate.

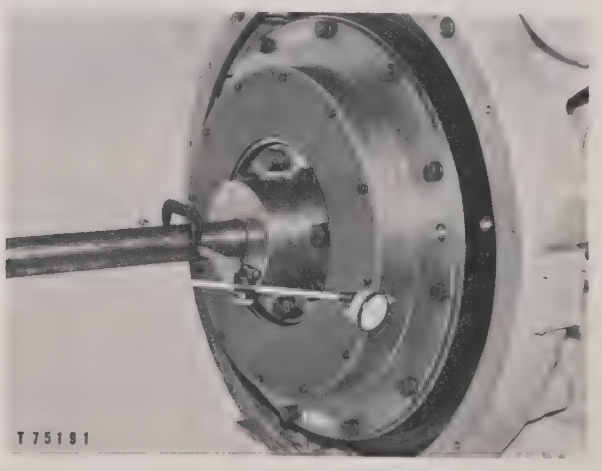
ALIGNING DRIVEN EQUIPMENT

Attach a dial indicator to the drive shaft as shown. Check both the face and O.D. runout of the drive coupling. A reading of .008" or less, total indicator movement, is admissible.



CHECKING FACE RUNOUT OF DRIVE COUPLING

If necessary, align the driven equipment by shifting the engine, driven equipment or pillow block for driven shaft. Depending upon the engine installation and the driven equipment, shims may be used to accomplish correct alignment.



CHECKING O.D. RUNOUT OF DRIVE COUPLING

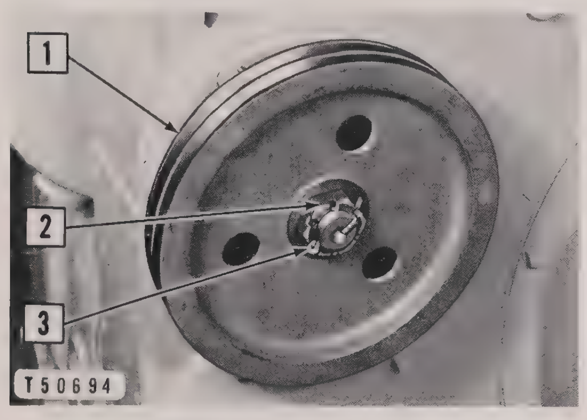
Auxiliary Drives

The auxiliary drives provide a means of driving engine attachments. Auxiliary drives are attached to the water pump shaft or the crankshaft or both.

AUXILIARY DRIVE
(Mounted on the Water Pump Shaft)

The auxiliary drive attached to the water pump shaft consists of a pulley, woodruff key, nut and cotter pin. It can be used to drive a generator.

Removal and Installation



AUXILIARY DRIVE REMOVAL

☐ **Remove**

1–Pulley. 2–Nut. 3–Cotter pin.

Remove the key after the pulley has been removed.

NOTE

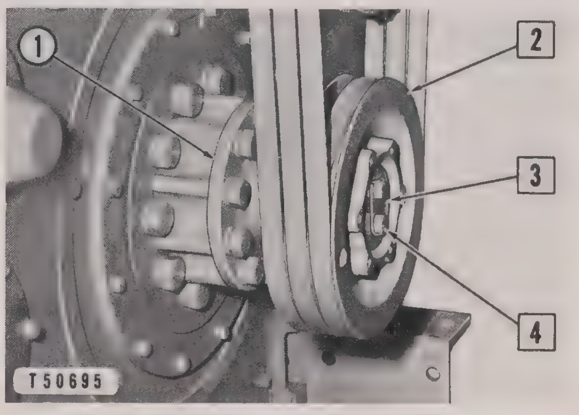
If the shaft is worn or damaged, the water pump must be removed and a new water pump shaft installed. See the covering topic.

Install in the reverse order of removal.

AUXILIARY DRIVE
(Crankshaft Mounted)

The auxiliary drive attached to the crankshaft consists of a tapered stub shaft with a pulley attached. Usually, it is used to drive the fan in applications where radiator cooling is used.

Removal and Installation



AUXILIARY DRIVE REMOVAL
(D379 Illustrated)

☐ **Remove**

1–Shaft. 2–Pulley. 3–Plate. 4–Bolts and locks.

CAUTION

On the D398 Engine, the bolts securing the stub shaft **(1)** also secure the vibration damper to the crankshaft. If the stub shaft is removed and the engine is to be operated, the standard vibration damper bolts, which are shorter, must be installed.

Install in the reverse order of removal.

Electric Starting Motors

Two 32 volt starting motors are used to start the engine if electric starting is used. Each starting motor contains a friction-clutch drive mechanism. It functions in a similar manner as other starting drive mechanisms except it uses a series of spring-loaded clutch plates which slip momentarily during engagement. The clutch thus serves to protect the pinion and ring gear from shock.

The starting motors used with a clockwise rotation engine have different drive mechanisms and armature rotation than the starting motors used with a counterclockwise rotation engine. For the difference in the appearance of the drive, see the topic, AIR STARTING SYSTEM.

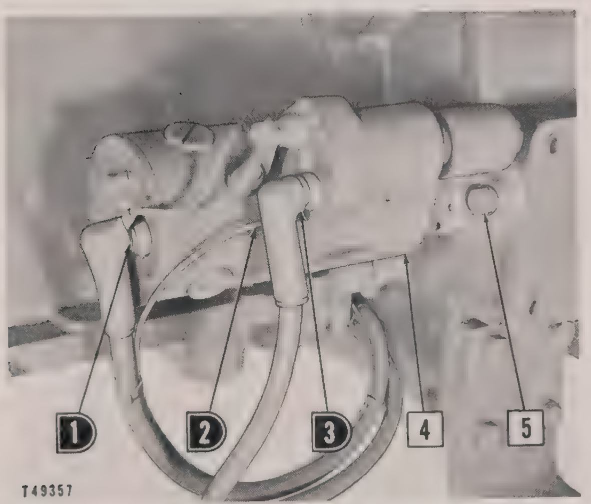
A heavy duty magnetic switch is used on each starting motor.

For the wiring diagrams, see the Operation and Maintenance Instructions.

WARNING

Extremely high currents flow through the circuit when the starting motors are operating. Therefore, care must be taken to prevent grounding the terminals accidentally because serious damage and injury could result.

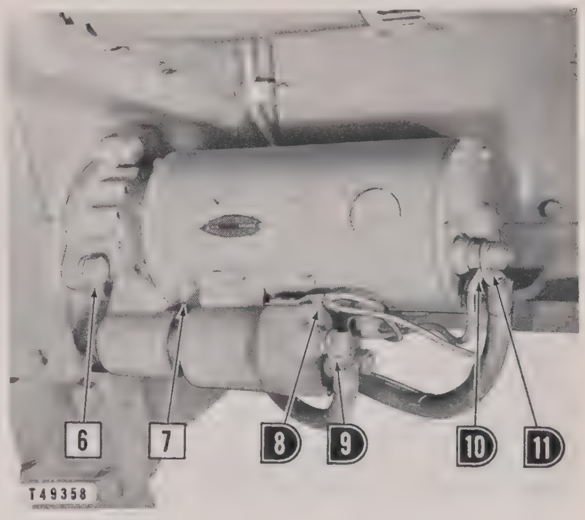
REMOVAL AND INSTALLATION



PREPARING TO REMOVE LEFT STARTING MOTOR

☐ Remove ◗ Disconnect

1–Cable and wire. 2–Wire. 3–Cable. 4–Starting motor. 5–Bolt (three).



PREPARING TO REMOVE RIGHT STARTING MOTOR

☐ Remove ◗ Disconnect

6–Bolt (three). 7–Starting motor. 8–Wire. 9–Cable. 10–Wire. 11–Cable.

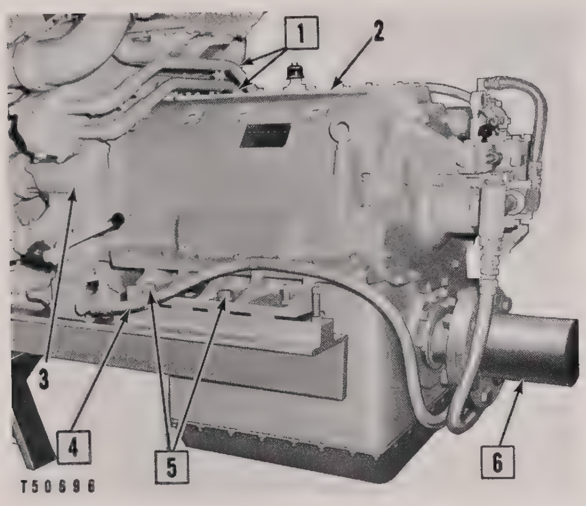
NOTE

Mark the cables, wires and terminals so they can be correctly connected when installing the starting motors.

Marine Gear

REMOVAL AND INSTALLATION

1. Drain the oil from the marine gear housing.
2. Drain the diesel engine cooling system.



PREPARING TO REMOVE THE MARINE GEAR

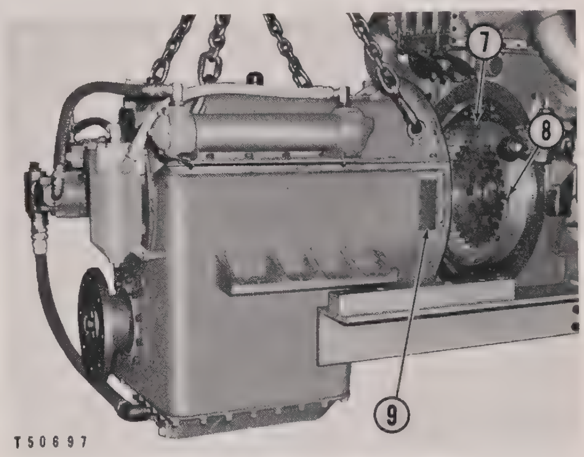
☐ **Remove**

1–Water lines to oil cooler. 2–Marine gear housing. 3–Flywheel housing. 4–Sump pump suction line. 5–Bolts. 6–Companion flange.

NOTE

The shims between the mounting brackets and support rails should be tied together as they need be correctly positioned upon installation.

3. Attach a hoist as illustrated and remove the bolts securing the marine gear housing **(2)** to the flywheel housing **(3)**. The marine gear weighs approximately 3000 lbs.
4. Separate the marine gear from the flywheel housing by removing the marine gear back away from the engine until the drive spider clears the drive ring **(7)**.



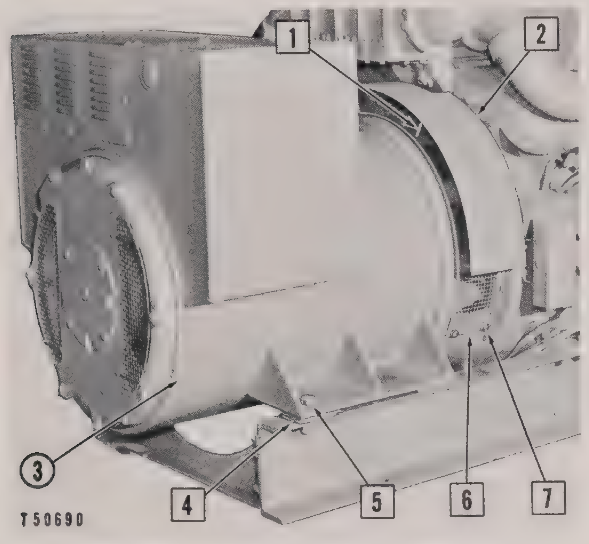
REMOVING THE MARINE GEAR
7–Drive ring. 8–Bolt. 9–Cover.

5. To replace the drive ring **(7)**, remove the bolts **(8)** securing it to the flywheel.
6. When installing the marine gear to the engine, the use of two ½" - 13 (NC) guide pins will aid in the alignment of the gear housing with the bore of the flywheel housing. With the covers **(9)** removed from each side, check the alignment of the drive spider and the rubber drive blocks with the drive ring while installing the marine gear.
7. The installation of the marine gear can be completed by connecting and tightening the lines and servicing the gear as outlined in the Operation and Maintenance Instructions.

Generator

REMOVAL

1. Disconnect and tape all electrical leads. The leads are marked with metal identification tags to aid in making the correct connections.

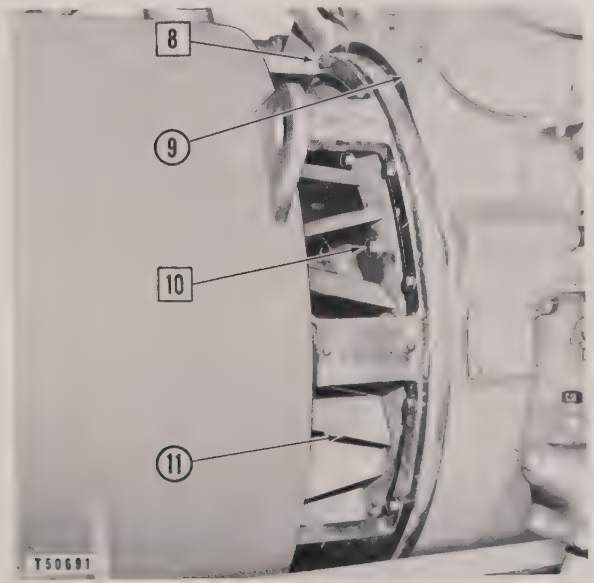


PREPARING TO REMOVE THE GENERATOR

☐ **Remove**

1–Bolts and spacers. 2–Drip cover. 3–Generator. 4–Shims. 5–Bolts. 6–Screen. 7–Bolts.

2. Remove the screens from the rear of the generator and slide heavy cardboard or fiber board in between the rotating field and the armature. This will prevent the rotating field from dropping and causing severe damage to the rotating field and armature when the generator is removed from the engine.



DISCONNECTING GENERATOR DRIVE COUPLING

☐ **Remove**

8–Bolts. 9–Flywheel housing. 10–Bolts. 11–Fan.

CAUTION

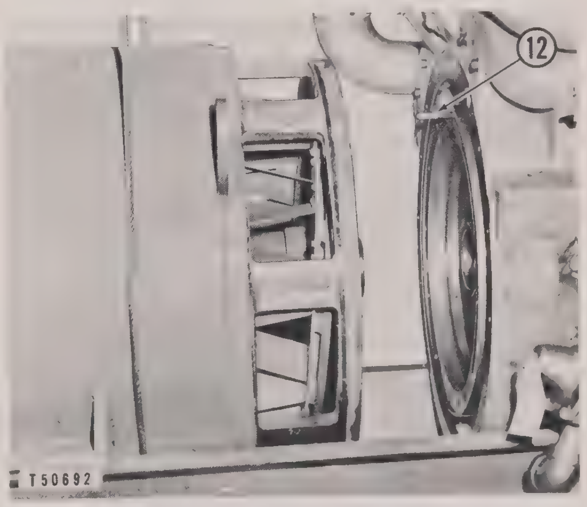
Do not pry against the generator fan blades to rotate the engine crankshaft and generator.

3. A $\frac{5}{8}''$ - 11 (NC) guide pin **(12)** installed through the fan **(11)** and adapter plate will facilitate removal and installation.

NOTE

The generator weighs approximately 6500 pounds.

4. Attach a suitable hoist to the generator **(3)** and move the generator away from the flywheel housing **(9)** as shown.



REMOVING THE GENERATOR

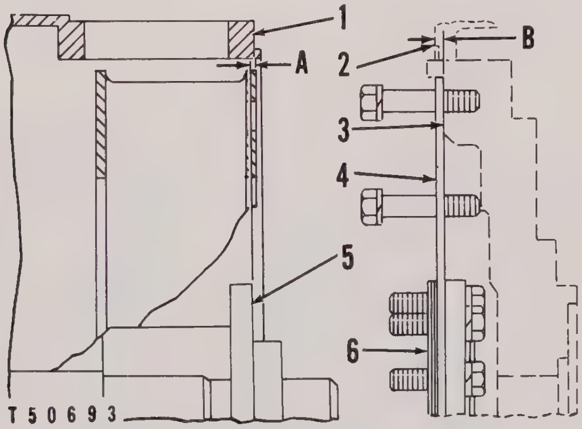
12–Guide pin.

INSTALLATION

Installation is in the reverse order of removal unless a new crankshaft, flywheel, flywheel housing, generator shaft or connecting parts are installed. If any of these parts are installed new, consideration must be given to the number of shims used between the generator shaft and the coupling plate assembly. Shims are used to center the generator rotor in the generator frame so the crankshaft end clearance is not restricted by the generator bearing clearance.

The correct number of shims is determined as follows:

1. With the engine crankshaft in the extreme forward position, measure the dimension **(B)** from the flywheel housing face **(2)** to the coupling plate assembly mounting face **(3)** of the flywheel. If the face of the flywheel is inside the face of the flywheel housing, add dimension **(B)** to .587″. If the face of the flywheel is outside the face of the flywheel housing, subtract dimension **(B)** from .587″. Call this dimension **(C)**.
2. Measure the thickness of the coupling plate **(4)**. Call this dimension **(D)**.
3. Subtract dimension **(D)** from dimension **(C)**. Call this dimension **(E)**.
4. Install the number of shims **(6)** required to provide a thickness equal to dimension **(E)** to the nearest .015″.



CALCULATING COUPLING DIMENSION
A–.587″. B–Distance to be measured. 1–Generator mounting face. 2–Flywheel housing face. 3–Coupling plate assembly mounting face on flywheel. 4–Coupling plate assembly. 5–Coupling plate assembly mounting face on hub. 6–Shims.

NOTE

If the same components are reinstalled, install the same shims which were previously used between the generator support brackets and the base. If a new generator frame, flywheel housing or base is installed, or if the original shims are lost, the correct number of shims can be determined as follows:

With the generator housing bolted tightly to the flywheel housing, measure the gap between the generator support brackets and the base near the rear bolt position. Raise the rear of the generator sufficiently to insert shims with a total thickness of .015″ more than the gap.

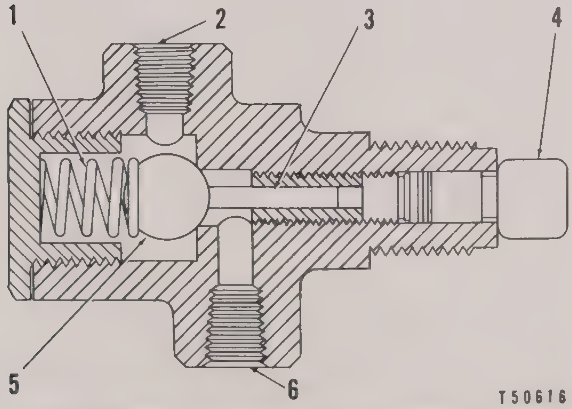
Water Temperature Shut-off Control Valve

OPERATION

The water temperature shut-off in itself is a control valve for the oil pressure shut-off, as it is actually the oil pressure shut-off that functions to stop the engine. The water temperature shut-off is used only with the oil pressure shut-off.

When the water temperature is normal, spring **(1)** holds ball **(5)** on its seat which prevents oil flowing from the oil pressure shut-off through port **(2)** of the water temperature shut-off and on into the engine crankcase through outlet port **(6)**. This allows oil pressure to build up in the safety shut-off system with the result that the oil pressure shut-off functions as described in the topic, SAFETY SHUT-OFF CONTROLS.

Occurrence of abnormally high engine water temperature heats the thermostatic assembly **(4)** which is immersed in engine water at the front of the manifold. As heat on the thermostatic assembly increases, it expands against the stem **(3)** which unseats the ball **(5)**. This allows oil held under pressure in the safety shut-off control system to return to the engine crankcase through the outlet port **(6)**. The resultant drop in pressure causes the oil pressure shut-off to shut down the engine. See the topic, SAFETY SHUT-OFF CONTROL.



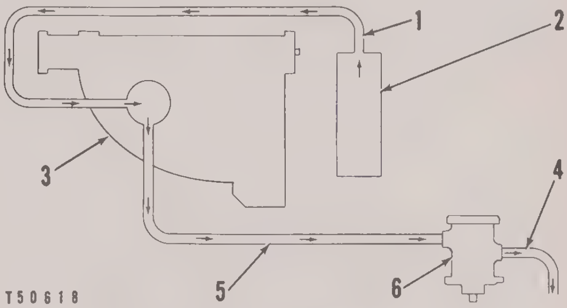
WATER TEMPERATURE SHUT-OFF CONTROL VALVE (CROSS-SECTION)
1–Spring. 2–Inlet port. 3–Stem. 4–Thermostatic assembly. 5–Ball. 6–Outlet port.

OIL FLOW

Engine oil under pressure enters line **(1)** from the auxiliary oil manifold **(2)** and flows behind the control piston in the oil pressure and overspeed shut-off control **(3)**. When a water temperature shut-off control valve is used, a line **(5)** connected to the oil pressure and overspeed shut-off supplies pressure oil to the valve **(6)**. When engine water temperature is not abnormally hot, the valve **(6)** remains closed and no oil can flow through the valve and into the dump line **(4)**.

Should the coolant temperature become excessive, the thermostatically controlled valve opens, as described in the previous topic, and permits oil to flow through the dump line and into the engine crankcase. Thus, a low oil pressure condition is actually simulated and the oil pressure shut-off control then stops the engine as further described in the topic, SAFETY SHUT-OFF CONTROLS.

After a shut-down caused by excessively high water temperature, depress reset button and reset the release rod as described in the topic, SAFETY SHUT-OFF CONTROLS.

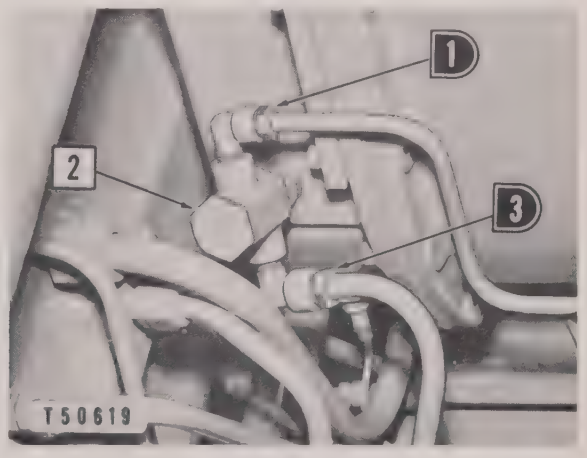


OIL FLOW – SCHEMATIC (TOP VIEW)
1–Oil inlet line. 2–Auxiliary oil manifold. 3–Safety shut-off control. 4–Dump line. 5–Oil line. 6–Water temperature shut-off control valve.

REMOVAL AND INSTALLATION

Drain the coolant until it is below the level of the valve **(2)**.

Install in the reverse order of removal, making sure the inlet side of the valve mates with the supply line.



VALVE REMOVAL
☐ **Remove** ◗ **Disconnect**
1–Oil supply line. 2–Valve. 3–Oil pump line.

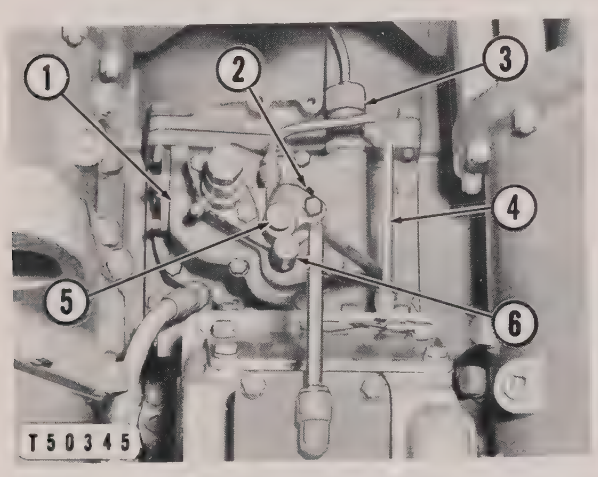
Safety Shut-off Control

INTRODUCTION

A combined overspeed and low oil pressure safety shut-off is provided for industrial engines, but is not standard equipment on marine engines.

The safety shut-off **(1)** is mounted in the V of the engine at the rear of the governor housing with the overspeed portion driven from the governor drive shaft.

Engine lubricating oil pressure is used to actuate the shut-off control. The plug **(2)** provides for a connection of oil pressure to a water temperature shut-off control valve. The line **(4)** supplies oil pressure to the shut-off control.



SAFETY SHUT-OFF CONTROL (FUEL SHUT-OFF ARRANGEMENT)
1–Safety shut-off control. 2–Plug (pressure oil connection to water temperature shut-off). 3–Fuel rack shut-off. 4–Pressure oil line to shut-off control. 5–Reset button. 6–Emergency manual shut-off button.

The emergency manual shut-off button **(6)** works in conjunction with the overspeed shut-off and provides the operator with an emergency shut-off.

The reset button **(5)** is used to reset the control after the engine has been stopped by the control.

NOTE

It is not necessary to reset the control after a normal shut-down.

The shut-off mechanisms receive lubricating oil from leakage past the oil pressure shut-off piston. An internal drain is provided by two drilled holes in the bottom of the housing.

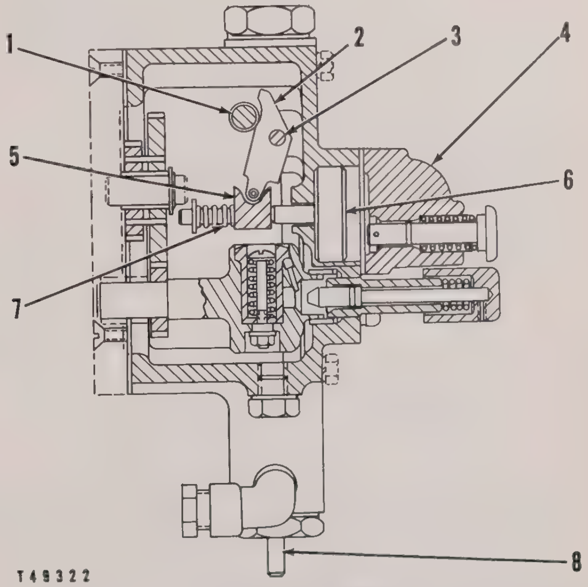
OPERATION

Low Oil Pressure Shut-off and Water Temperature Shut-off

The oil pressure control will stop the engine should the lubricating oil pressure drop below the safe operating range, or if an overheating condition occurs. Excessively hot water opens a shut-off control valve which simulates low oil pressure.

Under normal engine operating conditions, engine lubricating oil is directed from the timing gear housing through supply line **(4)**, see previous illustration, to the cover **(4)**. This oil is then directed against the control piston **(6)**.

One end of the worm follower **(2)** is piloted into the guide **(5)**. The follower is free to pivot about a fixed shaft **(3)** in the housing and is actuated by the horizontal movement of the guide **(5)**.

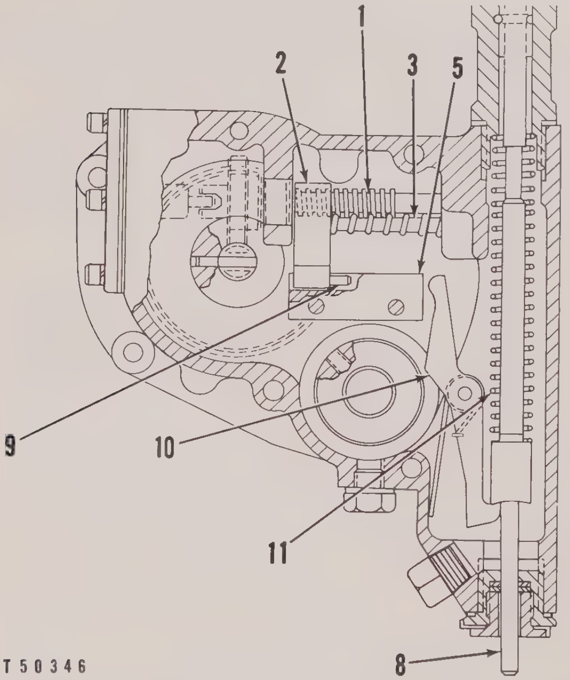


SHUT-OFF CONTROL (CROSS SECTIONAL SIDE VIEW – NORMAL OPERATION)
1–Worm shaft. 2–Follower. 3–Follower shaft. 4–Cover. 5–Guide. 6–Piston. 7–Spring. 8–Release rod.

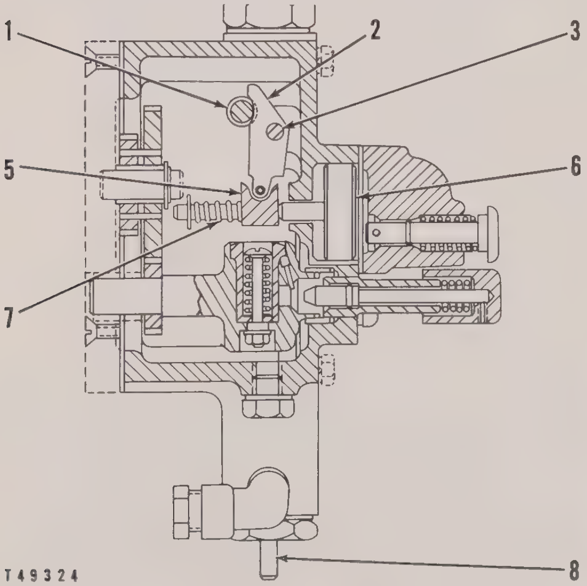
The worm shaft **(1)** is driven by the governor drive shaft and rotates any time the engine is operating.

When the engine oil pressure is within the safe operating range, the piston **(6)** is held against the guide **(5)** compressing the spring **(7)** and pivoting the follower **(2)** out of mesh with the worm shaft **(1)**.

Should the lubricating oil pressure drop below normal operating range, the oil pressure actuating the piston **(6)** will also drop and the spring **(7)** will force the guide **(5)** back and the piston **(6)** to the rear of its chamber, and cause the follower **(2)** to pivot on shaft **(3)** and mesh with the worm shaft **(1)**.

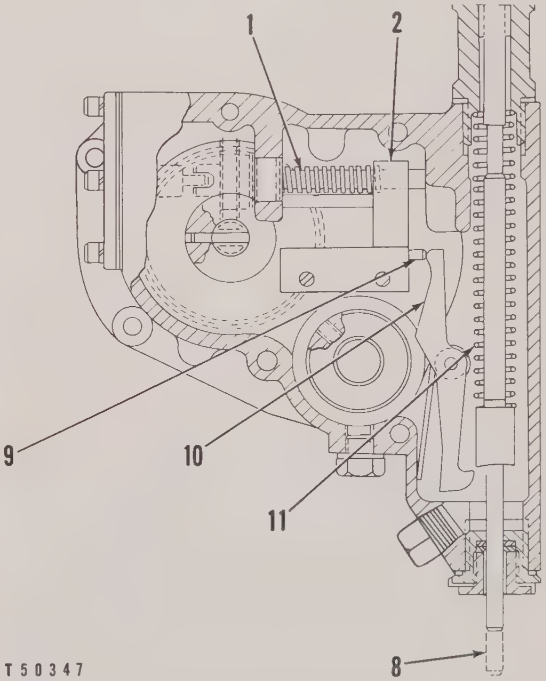


SHUT-OFF CONTROL
(CROSS SECTIONAL TOP VIEW – NORMAL OPERATION)
1–Worm shaft. 2–Follower. 3–Follower shaft. 5–Guide. 8–Release rod. 9–Pin. 10–Release lever. 11–Spring.



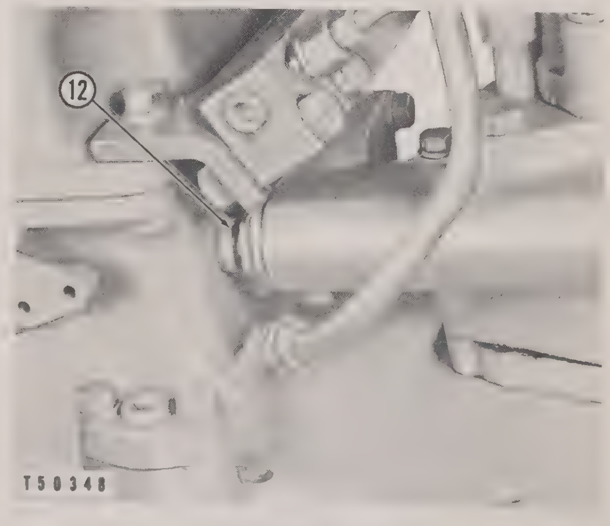
SHUT-OFF CONTROL
(CROSS SECTIONAL SIDE VIEW DURING SHUT-OFF OPERATION)
1–Worm shaft. 2–Follower. 3–Follower shaft. 5–Guide. 6–Piston. 7–Spring. 8–Release rod.

With the follower **(2)** engaged with the worm shaft **(1)**, the follower will travel the length of the worm shaft **(1)** which is turning at one-half engine speed. As the follower reaches the end of its travel, the pin **(9)** on the follower makes contact with the release lever **(10)**. The release lever is then tripped and releases the rod **(8)** which is forced downward by the spring **(11)**.



SHUT-OFF CONTROL
(CROSS SECTIONAL TOP VIEW DURING SHUT-OFF OPERATION)
1–Worm shaft. 2–Follower. 8–Release rod. 9–Pin. 10–Release lever. 11–Spring.

The release rod **(8)** moves forward to contact a spring loaded plunger **(12)** in the rear of the governor drive housing. The plunger then moves forward contacting the lever assembly in the governor drive housing, moving it to the off position and stopping the engine.



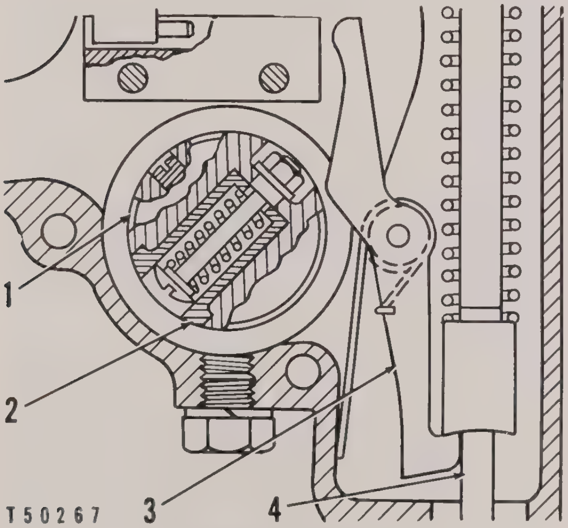
RACK SHUT-OFF
12–Plunger.

Overspeed Shut-off

Should an overspeeding condition occur, the overspeed shut-off control located in the shut-off control housing will actuate the release rod and then the fuel rack shut-off.

The overspeed carrier assembly **(1)** is driven by the governor drive shaft and rotates whenever the engine is operating. Within the carrier flange is a rotating weight **(2)** held toward the center of the carrier shaft by an adjusting screw, spring and nut.

As the engine RPM increases, the centrifugal force acting on the weight increases and the weight moves out of the carrier flange. This movement of the weight continues until the spring force (tending to hold the weight in) is equal to the centrifugal force (tending to throw the weight out).



OVERSPEED CONTROL
1–Carrier assembly. 2–Rotating weight. 3–Release lever. 4–Release rod.

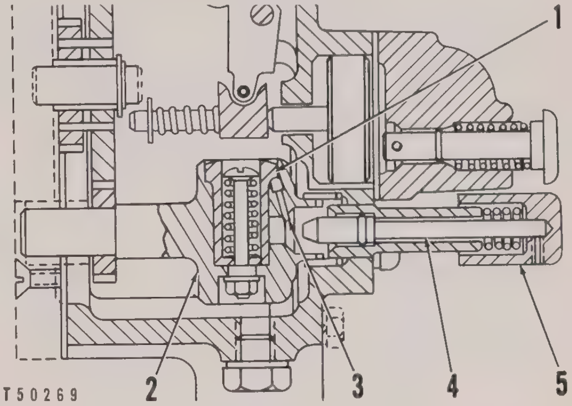
When the engine overspeeds, the weight will continue to move out of the carrier flange until it makes contact with the release lever **(3)** and releases the release rod **(4)** which actuates the fuel shut-off linkage and stops the engine.

Emergency Manual Shut-off Button

The emergency shut-off button **(5)** is never used for normal shut-down. Under normal conditions all load would be first removed from the engine and the engine RPM lowered to low idle before the engine is shut off.

If a emergency situation is encountered where the engine should be shut down immediately, push the emergency shut-off button and hold the button in until the release lever rod has been released.

By pushing the button **(5)**, the plunger **(4)** acts against the pin **(3)** which forces the spring-loaded weight **(1)** out of the carrier assembly **(2)** creating the same condition as overspeeding.



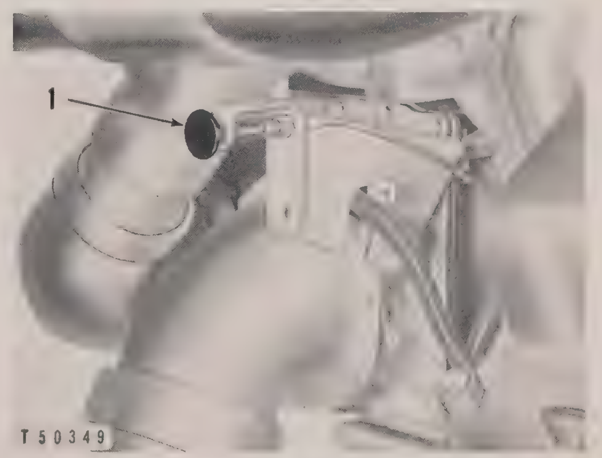
EMERGENCY SHUT-OFF
1–Weight. 2–Carrier assembly. 3–Pin. 4–Plunger. 5–Button.

RESETTING THE CONTROL

Whenever the engine has been shut down by the safety shut-off control, the reason for the shut-down must be corrected and the control reset before the engine can be restarted.

Overspeed and Emergency Manual Shut-down

The spring-loaded release rod is relatched by pulling out on the knob **(1)**.

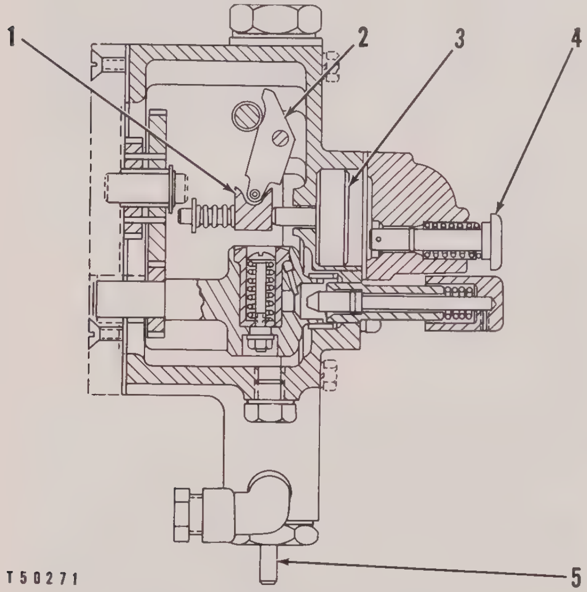


SHUT-OFF CONTROL RESET
1–Knob.

The engine can now be started

Low Oil Pressure, Water Temperature Shut-down

Push the reset button **(4)** on the top of the shut-off control housing. This manually moves the control piston **(3)** and pin against the follower guide **(1)**. The movement of the guide pivots the worm follower **(2)** away from the end of the worm shaft and allows the spring to return the follower to the start of the worm shaft threads.



SHUT-OFF CONTROL RESET
1–Follower guide. 2–Follower. 3–Piston. 4–Reset button. 5–Release rod.

Latch the spring-loaded release rod **(5)** by pulling out on the overspeed shut-down reset knob. See the topic, OVERSPEED AND EMERGENCY MANUAL SHUT-DOWN.

The engine can now be started.

NOTE

In cold weather operation it may be necessary to push the reset button momentarily while cranking the diesel engine to prevent actuating the shut-off control. This is necessary as the oil pressure may not reach the operating range rapidly enough due to the longer cranking period usually encountered under these conditions.

Under normal operation conditions, lubricating oil pressure will reach the operating range before the follower has reached the limit of travel and actuates the release lever and rod.

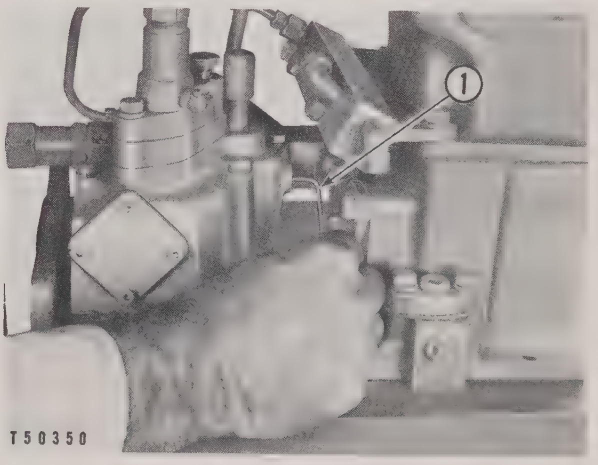
OVERSPEED CONTROL ADJUSTMENT

The overspeed control mechanism is adjusted at the factory and should not be changed unless the carrier assembly has been disassembled or the adjustment disturbed in some way. The overspeed control is originally set to shut down the engine if the engine RPM rises more than 18% above full load RPM.

The adjustment is made by removing the plug from the front of the shut-off housing to gain access to the weight adjusting screw. It may be necessary to rotate the flywheel until the adjusting screw can be reached with an offset screwdriver **(1)** as illustrated.

CAUTION

Always turn the crankshaft in the direction of normal rotation. If the crankshaft is turned in the opposite direction it is possible to damage the worm shaft and follower.



ADJUSTING THE WEIGHT SPRING TENSION
1–Offset screwdriver.

One complete turn of the adjusting screw will vary the maximum overspeed limit from 45 to 50 RPM. Clockwise rotation of the adjusting screw will compress the spring and raise the maximum speed limit, while counterclockwise rotation of the screw will allow the spring to expand and lower the maximum speed limit.

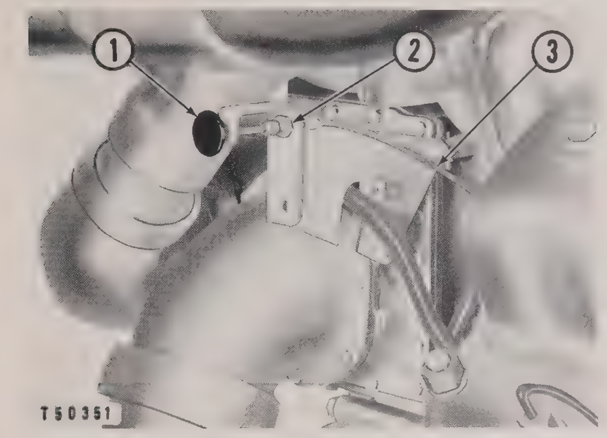
SAFETY SHUT-OFF CONTROL

Removal and Installation

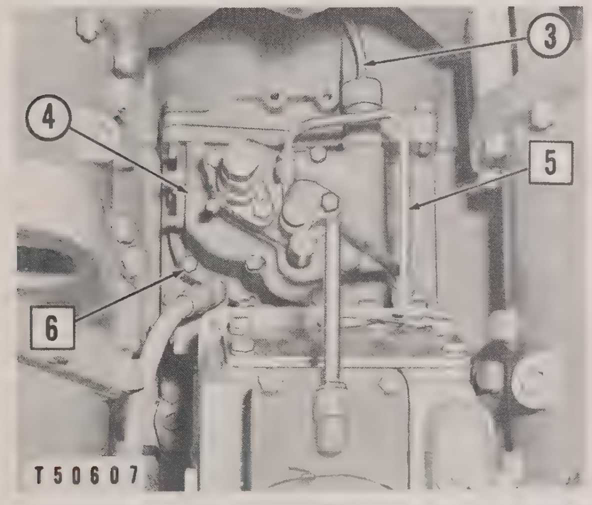
Remove the knob **(1)** and nut **(2)** and slide the cable **(3)** free of the support bracket.

Remove the safety shut-off control **(4)** and cable **(3)** as a unit.

Inspect all parts for wear or damage and replace if necessary.



PREPARING TO REMOVE SAFETY SHUT-OFF CONTROL
1–Knob. 2–Nut. 3–Cable.

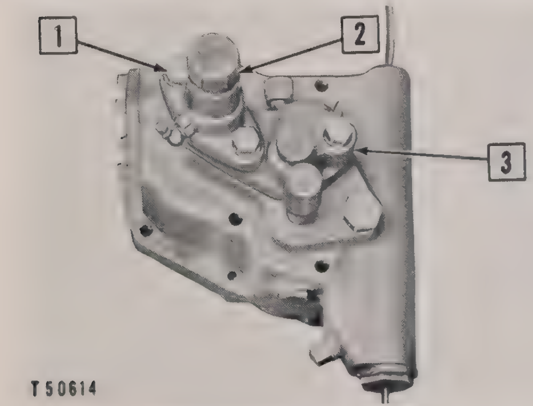


PREPARING TO REMOVE SAFETY SHUT-OFF CONTROL

☐ **Remove**

3–Cable. 4–Safety shut-off control. 5–Oil line. 6–Bolts (five).

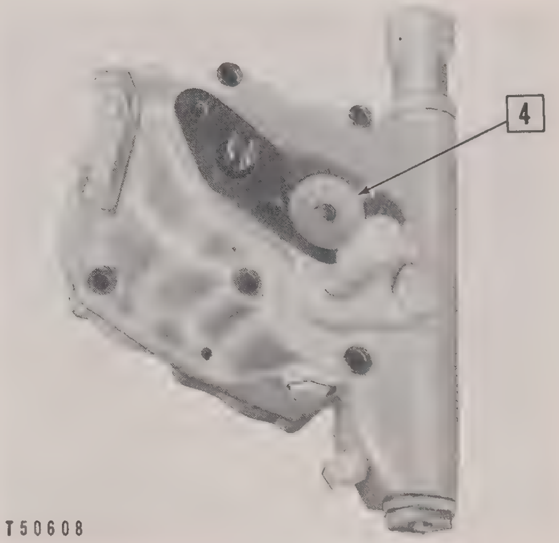
Reset Button and Piston Removal and Installation



REMOVING COVER ASSEMBLY

☐ **Remove**

1–Bolts (three). 2–Tachometer drive housing assembly. 3–Cover assembly.



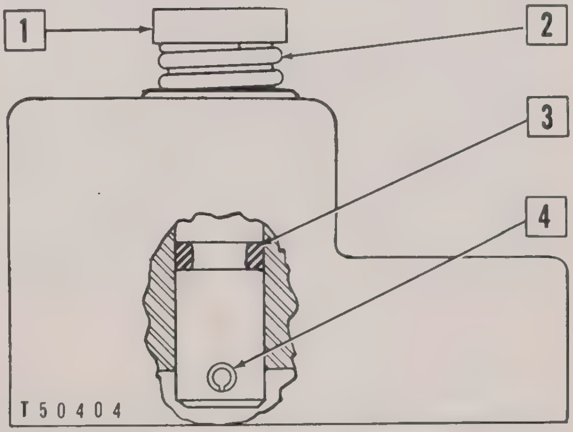
REMOVING PISTON

☐ **Remove**

4–Piston.

Replace the mounting gasket if necessary.

Reset Button Disassembly and Assembly



RESET BUTTON DISASSEMBLY

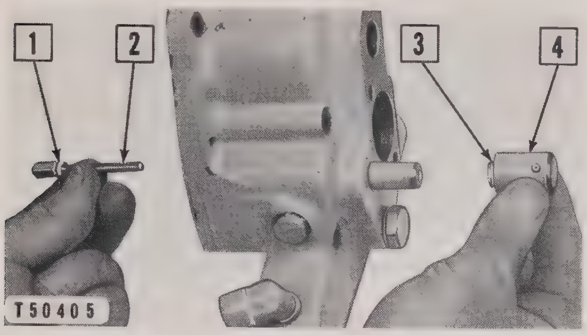
☐ **Remove**

1–Plunger. 2–Spring. 3–O-ring seal. 4–Pin.

Inspect the O-ring seal (3) and replace if damaged.

Emergency Shut-off Button Removal and Installation

Inspect the O-ring seal (1) and replace if damaged.



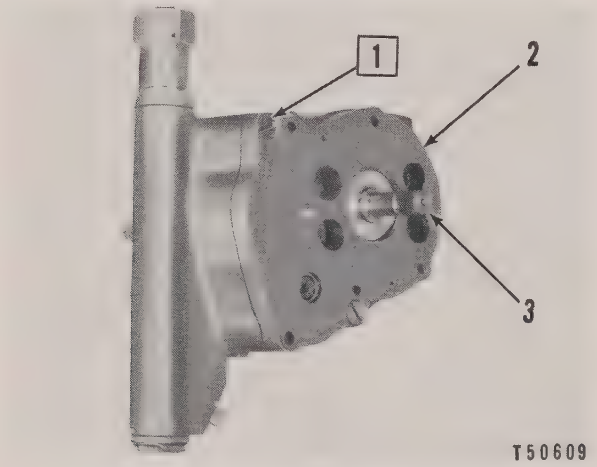
EMERGENCY SHUT-OFF BUTTON REMOVAL

☐ Remove

1–O-ring seal. 2–Plunger. 3–Spring. 4–Button.

Inspect the plunger **(2)** for wear or damage and replace if necessary.

Removal and Installation of Drive Assembly



DRIVE AND ADAPTER REMOVAL

☐ Remove

1–Screw (two). 2–Adapter assembly. 3–Drive shaft.

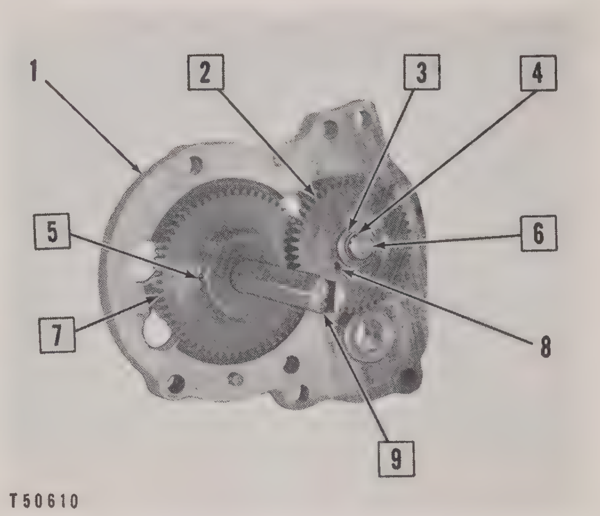
The drive shaft **(3)** and adapter assembly **(2)** should be removed as a unit.

Disassembly and Assembly of Drive Assembly

NOTE

After removal, the gear assembly **(2)**, consisting of two gears, one spacer, a bearing, and two spring pins **(8)**, can be disassembled by driving out the spring pins.

Inspect all parts for wear or damage and replace if necessary.



DRIVE ASSEMBLY DISASSEMBLY

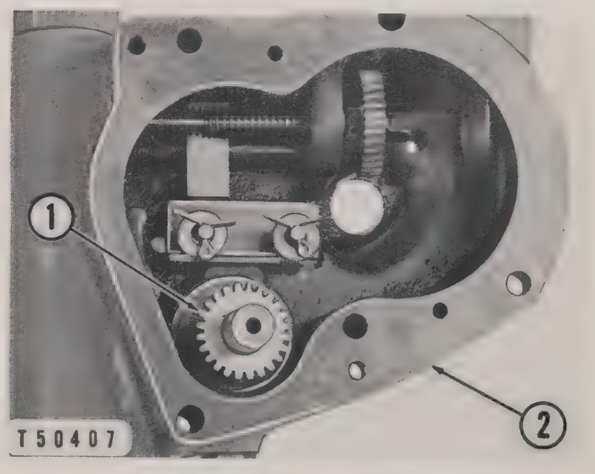
☐ Remove

1–Adapter. 2–Gear assembly. 3–Washer. 4–Snap ring. 5–Roll pin. 6–Shaft. 7–Gear. 8–Spring pins (two). 9–Drive shaft.

Carrier and Weight Disassembly and Assembly

With the adapter and drive shaft removed, the carrier and weight assembly **(1)** can be removed from the housing **(2)** and disassembled in the following manner:

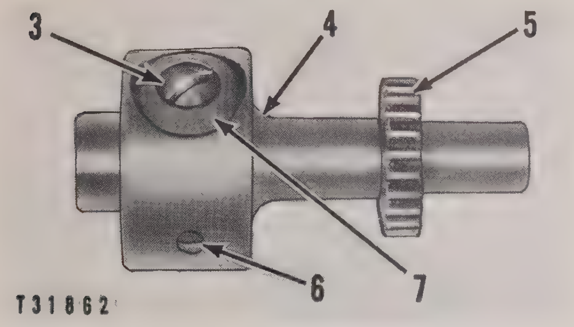
1. Using a suitable puller, remove the gear **(5)** and replace if worn or damaged.
2. Clean up the staked area around the screw **(6)** and remove the screw from the carrier **(4)**.



CARRIER AND WEIGHT REMOVAL
1–Carrier and weight assembly. 2–Housing.

NOTE

The screw **(6)** is both a guide for the weight and a safety device to keep the weight from flying out should the bolt **(3)** break for any reason.

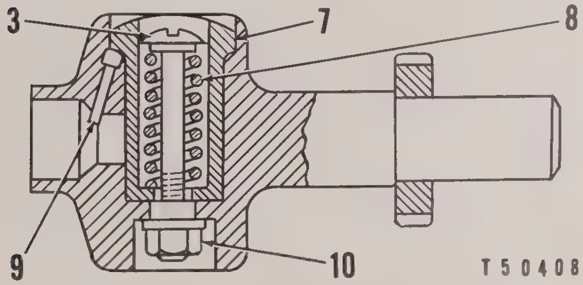


CARRIER DISASSEMBLY
3–Screw. 4–Carrier. 5–Gear. 6–Screw. 7–Weight.

NOTE

When removing the screw **(3)**, count the number of turns required to remove. When installing the screw, install with the same number of turns. After the safety shut-off has been installed on the engine, see the topic, OVERSPEED CONTROL ADJUSTMENT.

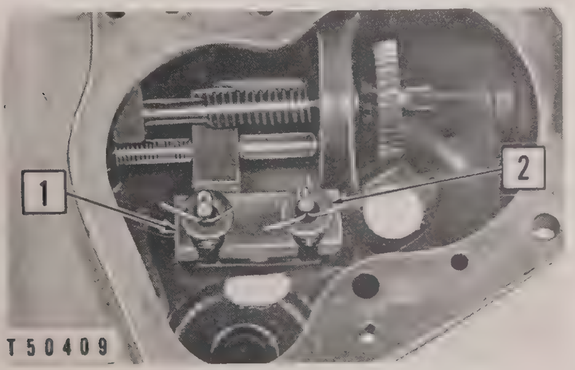
3. Remove the screw **(3)**, nut **(10)**, spring **(8)**, weight **(7)** and pin **(9)** from the carrier **(4)**.



CARRIER DISASSEMBLY
3–Screw. 7–Weight. 8–Spring. 9–Pin. 10–Nut.

4. Assemble in reverse order of disassembly, restaking the area around the screw **(6)**.

Guide Removal and Installation

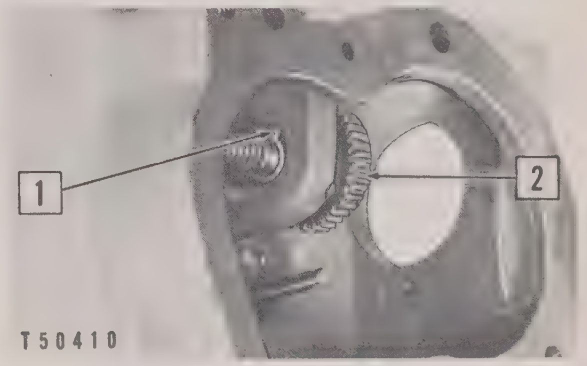


GUIDE REMOVAL

☐ Remove

1–Guide. 2–Cotter pins, washers, and springs (two).

Worm Shaft and Follower Removal and Installation



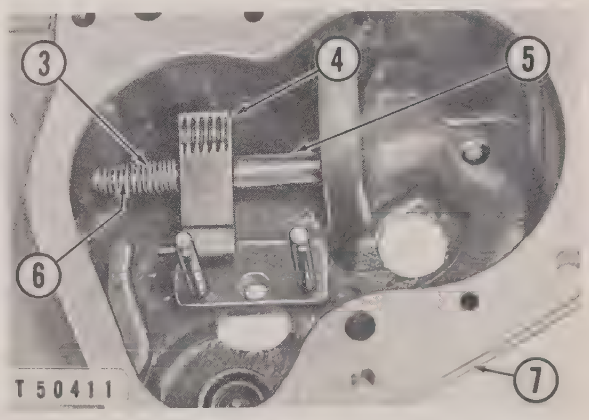
WORM SHAFT REMOVAL

☐ Remove

1–Snap ring. 2–Worm shaft.

NOTE

The follower shaft **(6)** is pressed into the housing **(7)**. To remove the spring **(3)**, follower **(4)** and spacer **(5)**, it is necessary to damage the shaft **(6)**.



FOLLOWER REMOVAL
3–Spring. 4–Follower. 5–Spacer. 6–Shaft. 7–Housing.

Install in the reverse order of removal, pressing in a new shaft **(6)**.

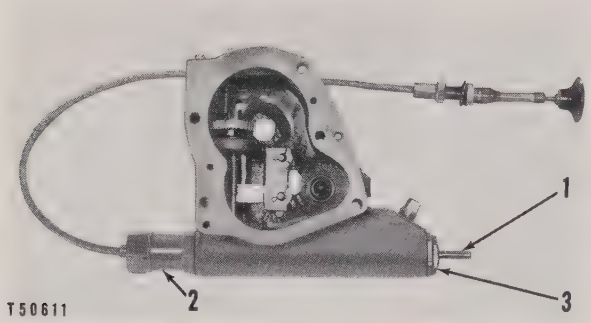
Safety Release Rod Removal and Installation

Back off the nut **(2)** and remove the release rod **(1)** and the nut **(2)** as an assembly. The nuts **(3)** then can be removed together.

NOTE

The nuts **(3)** serve only as a guide for the lower end of the release rod **(1)**.

Install in the reverse order of removal.



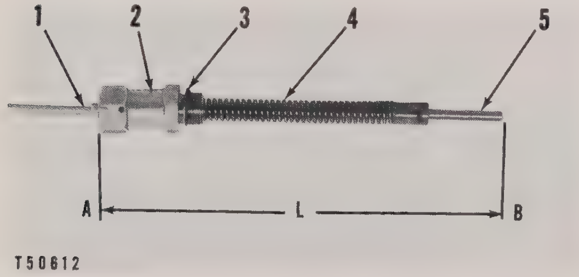
RELEASE ROD REMOVAL
1–Release rod. 2–Nut. 3–Nuts (two).

Safety Release Rod Disassembly and Assembly

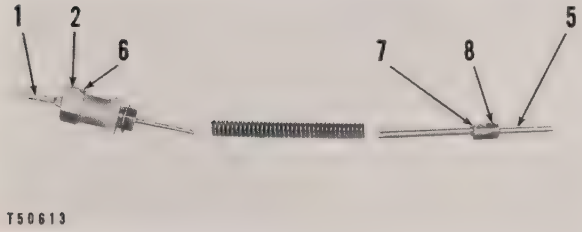
NOTE

Before disassembling the release rod assembly, take an overall length measurement **(L)** of the assembly from point A to point B. This measurement will be necessary for correct assembly of the release rod.

1. Grasp the cable **(1)** and nut **(2)** and turn the rod **(5)** counterclockwise until they separate.



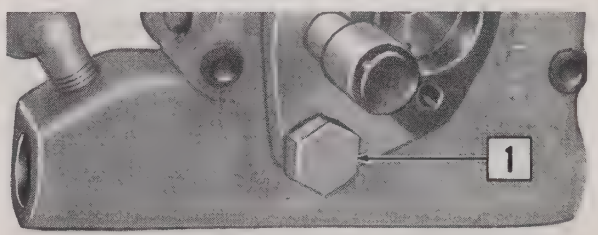
PREPARING TO DISASSEMBLE RELEASE ROD
1–Cable. 2–Nut. 3–Washer. 4–Spring. 5–Release rod. A and B–Extreme points of release rod. L–Overall length of rod.



DISASSEMBLING RELEASE ROD
1–Cable. 2–Nut. 5–Release rod. 6–Spring pin. 7–Collar. 8–Spring pin.

2. To separate the cable **(1)** from the nut **(2)**, drive out the spring pin **(6)**.
3. Remove the spring pin **(8)** to separate the release rod **(5)** from the collar **(7)**.
4. Inspect all parts for wear or damage and replace if necessary.
5. Assemble in the reverse order if disassembly, and adjust the release rod assembly to the length **(L)** previously measured.

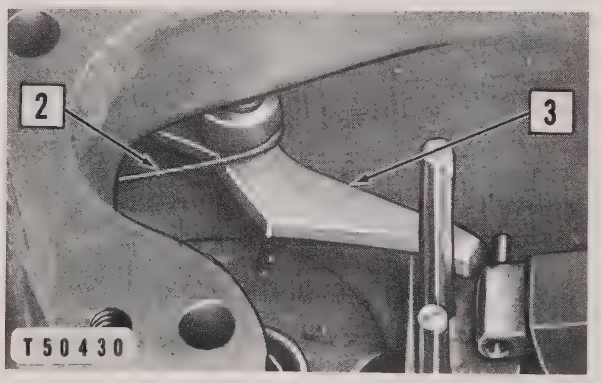
Release Lever Removal and Installation



PREPARING TO REMOVE RELEASE LEVER

☐ Remove

1–Bolt.



RELEASE LEVER REMOVAL

☐ Remove

2–Spring. 3–Lover.

Inspect all parts for wear or damage and replace if necessary.

Governor Air Actuator

INTRODUCTION

The governor air actuator provides a variable speed, positive action remote control for the diesel engine. The actuator operates on an external supply of compressed air through a range of 10 PSI to a minimum pressure of 65 PSI at high idle. To avoid damage within the actuator, the air supply should never exceed a maximum pressure of 80 PSI.

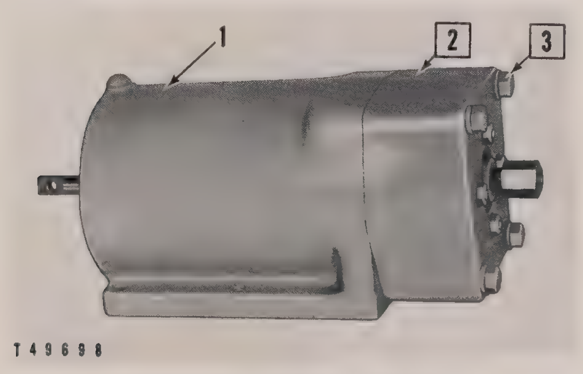
Air pressure on the diaphragm in the actuator varies the travel of the rod, sleeve and link. This controls the governor through the linkage movement.

This actuator has a two-part housing, which permits inspecting or replacing the diaphragm without disturbing the adjustment of the high or low idle positions, or the actuator spring preload. See the topic, DIAPHRAGM REPLACEMENT.

DIAPHRAGM REPLACEMENT

On most installations, the diaphragm can be replaced without removing the governor air actuator housing from the diesel engine.

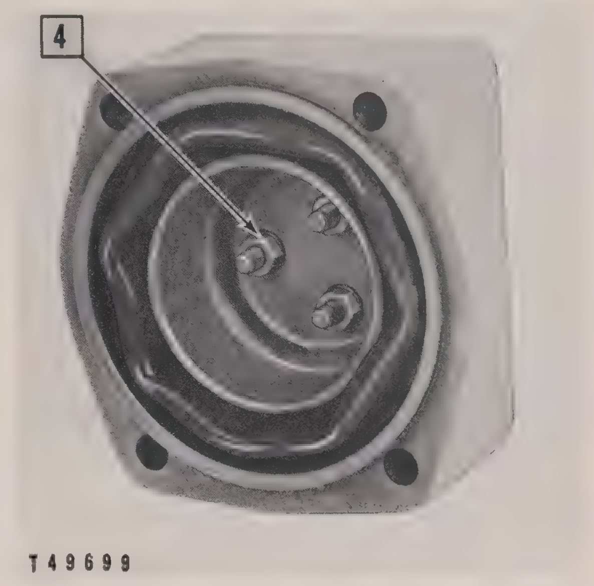
Shut off the air and disconnect the air line to the governor air actuator if it is located on the engine.



DIAPHRAGM HOUSING REMOVAL

☐ Remove

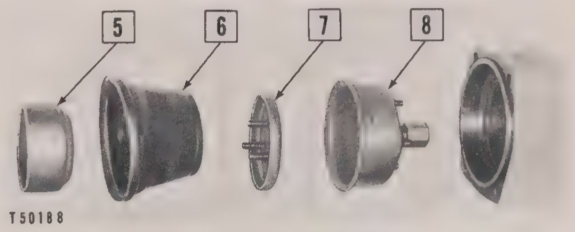
1–Housing. 2–Diaphragm housing. 3–Bolts (four).



DIAPHRAGM HOUSING

☐ Remove

4–Nut (three).



DIAPHRAGM REMOVAL

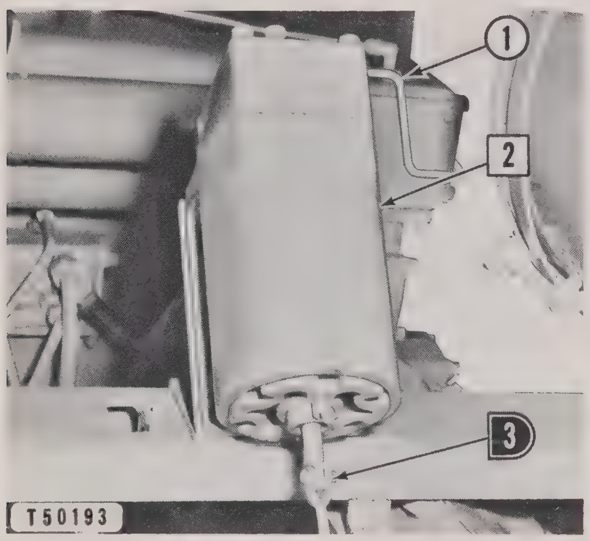
☐ Remove

5–Guide. 6–Diaphragm. 7–Clamp. 8–Clamp.

Install the parts in the reverse order of removal. Coat the diaphragm with liquid soap for easier installation in the housing. Check for air leaks.

REMOVAL AND INSTALLATION

Disconnect the air supply line (1) from the diaphragm housing.



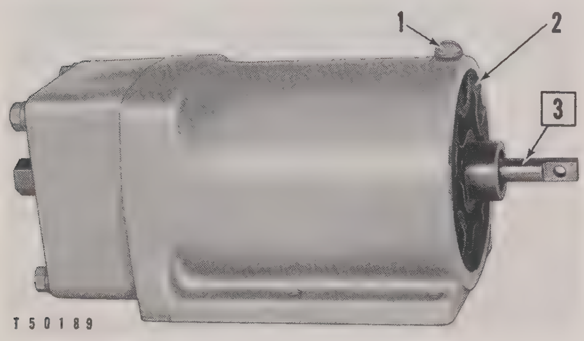
AIR ACTUATOR REMOVAL

☐ **Remove** ◗ **Disconnect**

1–Air supply line. 2–Air actuator. 3–Linkage.

DISASSEMBLY AND ASSEMBLY

If access to the diaphragm only is desired, see the topic, DIAPHRAGM REPLACEMENT.

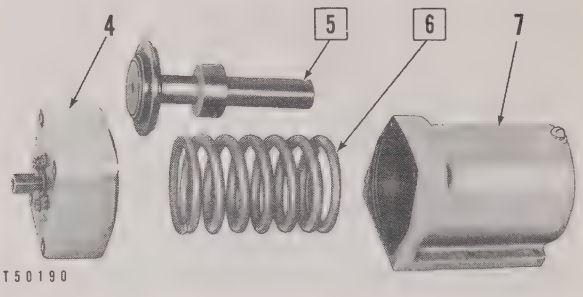


PREPARING TO DISASSEMBLE ACTUATOR

☐ **Remove**

1–Lockscrew. 2–Retainer nut. 3–Rod.

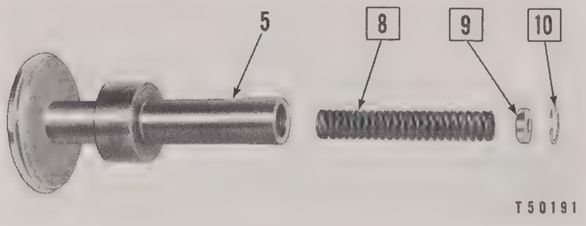
1. Loosen the lockscrew **(1)** until it does not protrude into the retainer nut **(2)**.
2. Turn the retainer nut **(2)** until the spring tension is released.
3. Remove the bolts and lockwashers securing the housings together, and separate the housings.
4. Remove the diaphragm housing **(4)**. For disassembly, see the topic, DIAPHRAGM REPLACEMENT.
5. Remove the retaining nut **(2)**.



PLUNGER AND SPRING REMOVAL

☐ **Remove**

4–Diaphragm housing. 5–Plunger. 6–Spring. 7–Housing.



DISASSEMBLING PLUNGER

☐ **Remove**

5–Plunger. 8–Spring. 9–Spacer. 10–Snap ring.

6. Inspect all parts for wear or damage and replace if necessary.

GOVERNOR AIR ACTUATOR ADJUSTMENTS

If the actuator has been disassembled, three adjustments should be performed after it is installed on the engine. Actuating air pressure for high and low idle positions should be adjusted, and the correct low and high idle settings should also be obtained.

Adjusting Actuator Air Pressure

1. Start the engine and permit it to run long enough to assure proper warm up.
2. Disengage the driven equipment. With an accurate tachometer, check the high and low idle RPM. If necessary, adjust the engine high and low idle adjusting screws as required to obtain specified engine RPM.
3. Shut the engine down.
4. Install an accurate air gauge **(1)** in the air line at a convenient point between the actuator air control and the actuator **(5)** as shown.
5. Check the air supply pressure to the actuator to determine if a minimum of 65 PSI air pres-

sure is available when the control valve is at full throttle. Maximum air pressure is not to exceed 80 PSI.

6. Place the governor hand control lever in the low idle position.
7. Move the actuator air control lever **(2)** slowly toward the open position, while observing the plunger **(3)**. The plunger should start to move when the air gauge registers 10 PSI.

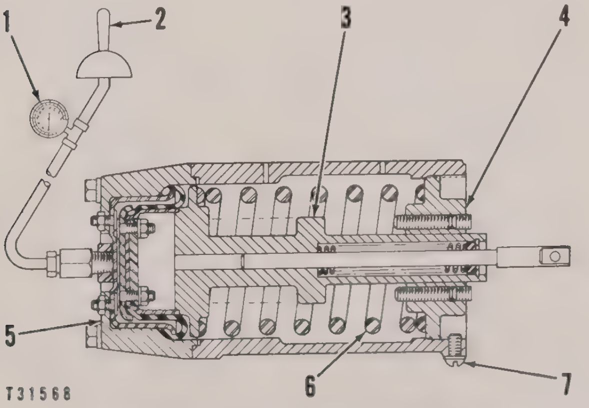
NOTE

If the plunger moves at a pressure less than 10 PSI, the preload must be increased. If more than 10 PSI pressure is required to move the sleeve, the preload must be decreased.

8. To change the preload on the actuator spring **(6)**, return the actuator air control lever to the low idle position.
9. Turn the lockscrew **(7)** out far enough to permit turning the retainer nut **(4)**.
10. To increase spring preload, turn the retainer nut clockwise. To decrease the preload, turn the retainer nut in a counterclockwise direction.
11. After the 10 PSI preload has been obtained, tighten the lockscrew **(7)** to lock the retainer nut **(4)** in place.

NOTE

It may be necessary to rotate the retainer nut to the nearest notch to align the lockscrew. Compensating pressure adjustment can be made in the remote control valve.



CHECKING AND SETTING ACTUATOR SPRING PRELOAD

1–Air gauge. 2–Actuator air control lever. 3–Plunger. 4–Retainer nut. 5–Actuator. 6–Actuator spring. 7–Lockscrew.

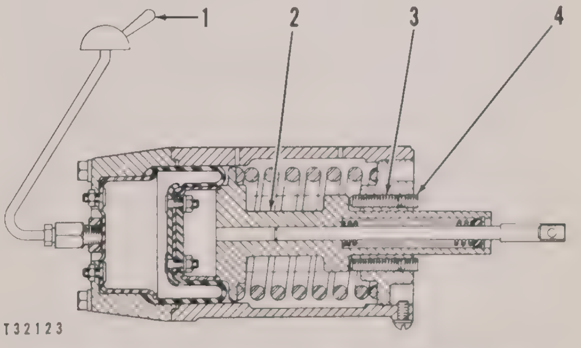
Setting Actuator Low Idle Stop Position

1. With the engine running and warmed up, check the actuator air control lever to be certain it is at the low idle position, or the position at which no air pressure is being delivered to the actuator.
2. With a hand tachometer, check the low idle RPM of the engine. If the check reveals a reading other than the low idle RPM specified, the actuator low idle adjustment must be changed.
3. To change the adjustment, remove the control linkage pins between the actuator rod and the governor.
4. To reduce the RPM, shorten the linkage rod. To increase the RPM, lengthen the linkage rod. The rod has an adjustable yoke and a selection of holes in the governor lever are provided for making the proper adjustment to give the desired low idle RPM.

Setting Actuator High Idle Stop Position

The high idle position of the actuator is controlled by adjusting the position of the two high idle adjusting screws **(3)**, since high idle is reached when the actuator plunger **(2)** moves into contact with the two high idle adjusting screws.

1. Start and warm up the engine.
2. Remove the two small setscrews **(4)** and back the two high idle adjusting screws **(3)** out several turns.
3. Move the governor hand control lever to the full open position. The engine will then be operating at the proper high idle RPM, which was previously established.
4. Move the actuator air control lever **(1)** slowly toward the full open position until the lever reaches the end of its travel.



SETTING AIR ACTUATOR HIGH IDLE POSITION

1–Air actuator control lever. 2–Plunger. 3–High idle adjusting screw. 4–Setscrew.

5. Turn the two actuator high idle adjusting screws **(3)** in a clockwise direction until they just make

contact with the actuator plunger **(2)**. Do not turn the screws beyond the point where contact is made.

6. Install the two setscrews **(4)** to prevent the adjusting screws from turning.
7. Return the actuator air control lever **(1)** to its low idle position.
8. Turn the high idle adjusting screw of the engine governor counterclockwise just enough to increase the high idle RPM of the engine to approximately 30 RPM above that specified.

NOTE

This will prevent the governor stop from acting as a stop for the actuator, thus eliminating the possibility of damaging the high idle adjusting screw within the governor.

9. Return the governor hand control lever to the low idle position and move the actuator air control lever **(1)** to the full open position.
10. Check the engine high idle RPM with the actuator at this position.

NOTE

The engine should be operating at specified high idle RPM if the adjusting screws **(3)** have been properly adjusted as described earlier.

11. If a reading other than that specified for the engine is obtained, minor adjustments should be made with the adjusting screws.

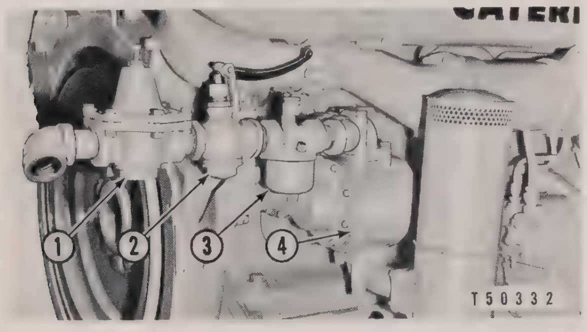
NOTE

Any time the adjusting screws **(3)** are turned, they both must be turned the same amount and same direction. This is essential since the plunger **(2)** must contact both adjusting screws simultaneously.

Air Starting System

INTRODUCTION

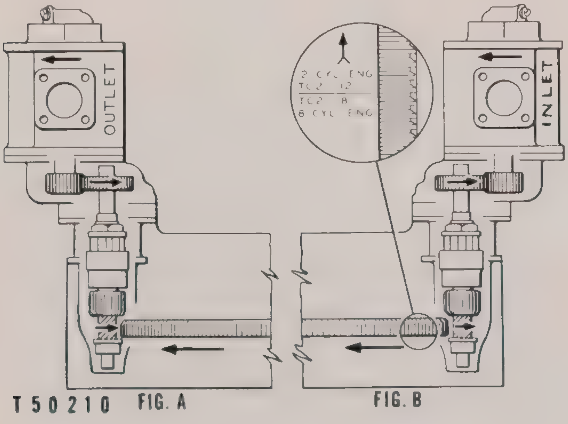
The air starting system shown is mounted on the right of the engine and is for a counterclockwise rotation engine. Counterclockwise and clockwise rotating air starting systems use the same parts with the exception of the drive mechanism. Therefore, the removal, installation, disassembly, and assembly are the same for both engine rotations.



AIR STARTING SYSTEM
1–Pressure regulating valve. 2–Balanced whistle valve. 3–Oiler. 4–Air motor.

There are four applications of the air starting system; counterclockwise, clockwise, and on either side of the engine as shown.

Fig. A shows the system mounted on the left and Fig. B shows the system mounted on the right of a counterclockwise rotation engine.

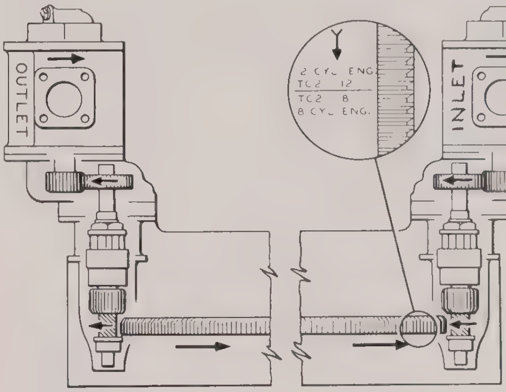


T50210 FIG. A FIG. B

AIR STARTING SYSTEM (COUNTERCLOCKWISE)

Fig. C shows the system mounted on the left and Fig. D shows the system mounted on the right of a clockwise rotation engine.

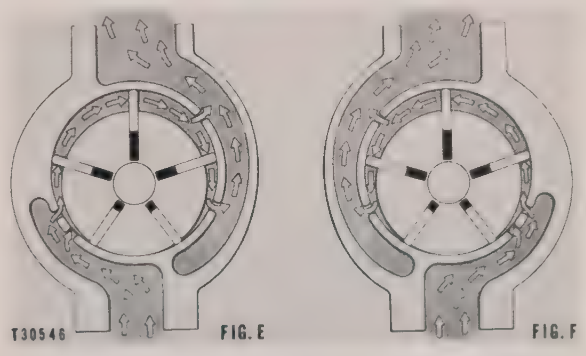
The chamfer on the flywheel ring gear teeth is different for counterclockwise and clockwise rotation engines. The inset shown in Fig. B illustrates the chamfer for counterclockwise rotation engines, while the inset in Fig. D illustrates the chamfer for clockwise rotation engines.



T50331 FIG. C FIG. D

AIR STARTING SYSTEM (CLOCKWISE)

Air for the starting system is furnished by an auxiliary compressor. Air is delivered through a receiver to the pressure regulating valve **(1)**, where the pressure is regulated to suitable starting pressure. The balanced whistle valve **(2)** controls the air passing to the air motor **(4)**. As the air passes through the oiler **(3)**, it picks up oil spray, which is deposited on the rotor and vanes of the air motor. The flow of air through the air motor is shown in Figure E for a counterclockwise rotation engine, and in Figure F for a clockwise rotation engine.

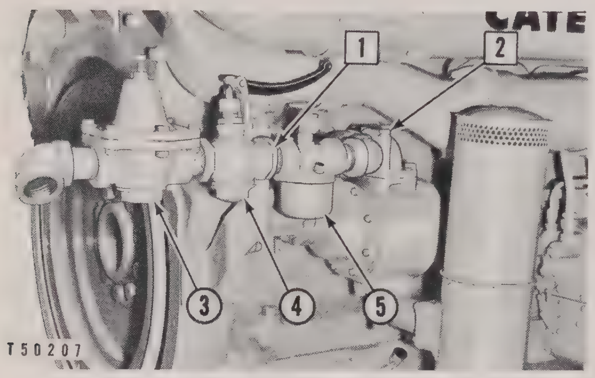


COUNTERCLOCKWISE CLOCKWISE
FLOW OF AIR THROUGH STARTING MOTOR
FRONT VIEW

PRESSURE REGULATING VALVE, BALANCED WHISTLE VALVE, AND OILER

Removal and Installation

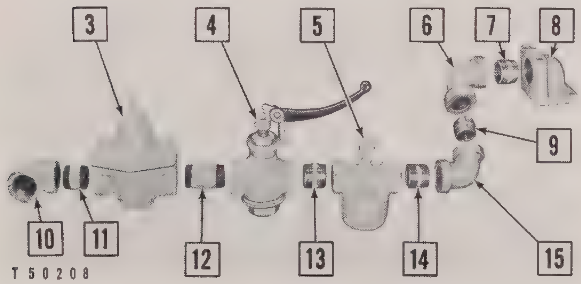
Remove the pressure regulating valve **(3)**, balanced whistle valve **(4)** and oiler **(5)** as a unit



PREPARING TO REMOVE PRESSURE REGULATING VALVE, BALANCED WHISTLE VALVE AND OILER

☐ **Remove**

1–U-bolt. 2–Bolts (four). 3–Pressure regulating valve. 4–Balanced whistle valve. 5–Oiler.



PRESSURE REGULATING VALVE, BALANCED WHISTLE VALVE, AND OILER

☐ **Remove**

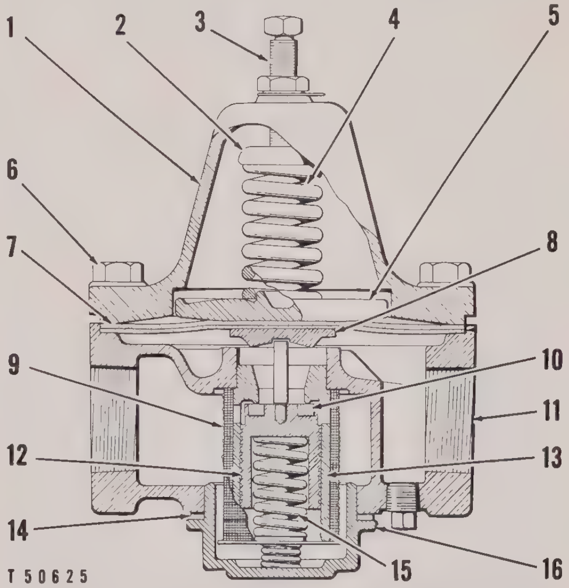
3–Pressure regulating valve. 4–Balanced whistle valve. 5–Oiler. 6–Elbow. 7–Nipple. 8–Elbow. 9–Nipple. 10–Elbow. 11, 12, 13, and 14–Nipples. 15–Elbow.

Inspect all parts for wear or damage and replace if necessary.

Pressure Regulating Valve

NOTE

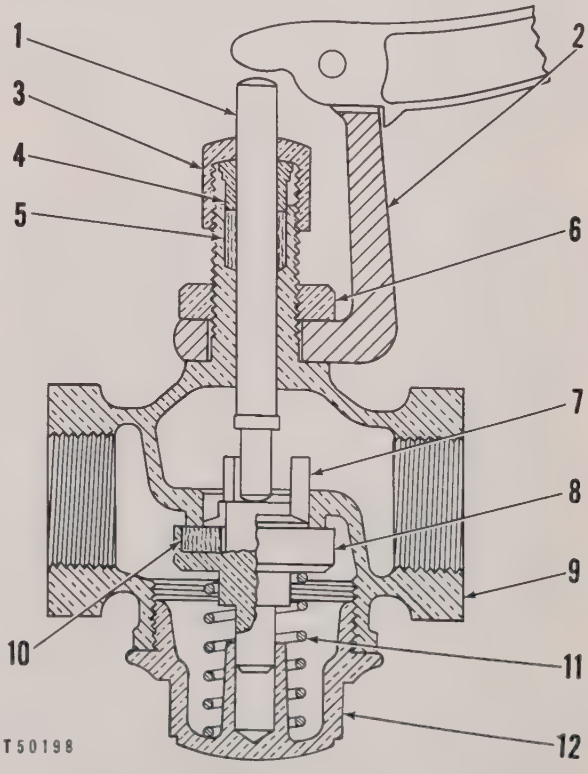
The regulator can be adjusted by turning the adjusting bolt **(3)**. With the regulator disconnected from the control valve, and connected to the air supply line, connect a gauge reading in PSI to the outlet side of the regulator and check the outlet pressure. With the inlet pressure at 250 PSI the outlet pressure should be 90-110 PSI. In cold weather it may be necessary to raise the outlet pressure delivered by the regulator. The outlet pressure should never exceed 150 PSI. After the pressure has been set, install the regulator.



PRESSURE REGULATING VALVE (CROSS SECTION)

1–Regulating chamber.
2–Button.
3–Adjusting bolt.
4–Spring.
5–Plate.
6–Bolt and nut (six).
7–Diaphragm.
8–Button.
9–Screen.
10–Seal.
11–Body.
12–Piston assembly.
13–Cylinder.
14–Gasket.
15–Spring.
16–Plug assembly.

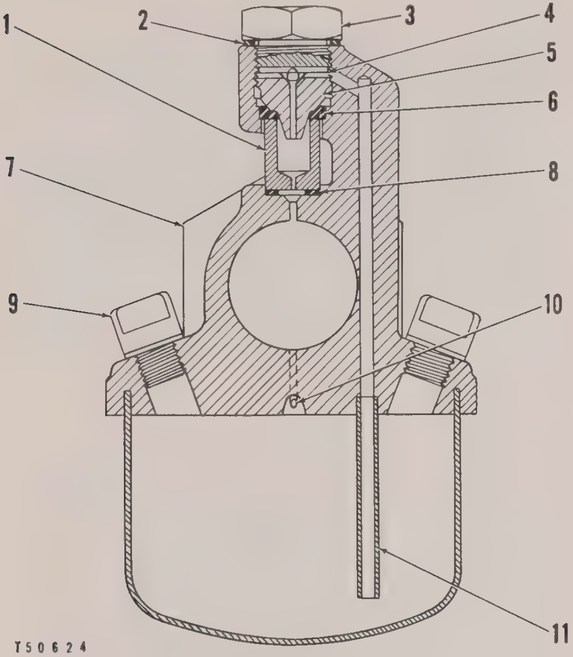
Balanced Whistle Valve



BALANCED WHISTLE VALVE (CROSS SECTION)

1–Stem.
2–Lever assembly.
3–Nut.
4–Gland.
5–Packing.
6–Locknut.
7–Nut.
8–Holder.
9–Body.
10–Disc.
11–Spring.
12–Cap.

Oiler



CROSS SECTION OF OILER

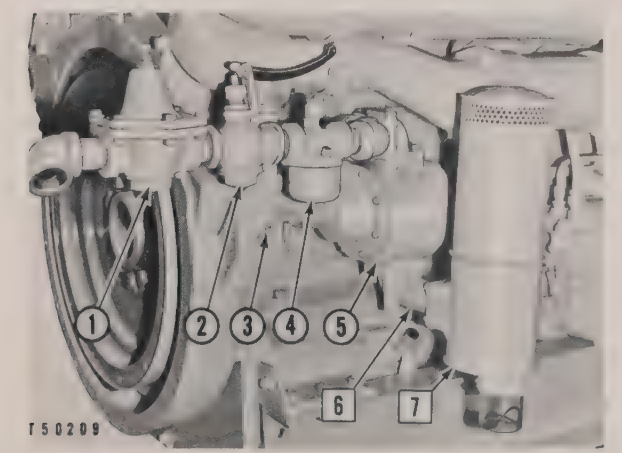
1–Tube. 2–Gasket. 3–Plug. 4–Oil hole. 5–Drip gland. 6–Washer. 7–Body assembly. 8–Washer. 9–Plug (two). 10–Air tube. 11–Syphon tube.

NOTE

The gland **(5)** must be below the oil hole **(4)** when assembled.

AIR STARTING MOTOR

Removal and Installation

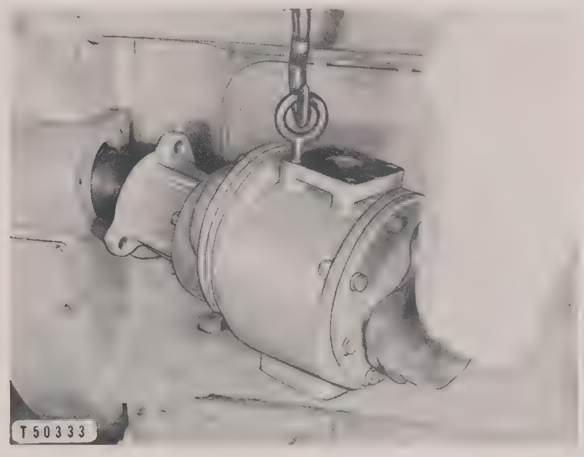


PREPARING TO REMOVE AIR STARTING MOTOR

☐ **Remove**

1–Pressure regulating valve. 2–Balanced whistle valve. 3–Bolt (three). 4–Oiler. 5–Air starting motor. 6–Elbow. 7–Silencer.

1. Shut off the air supply to the pressure regulating valve **(1)**.
2. Remove the pressure regulating valve **(1)**, balanced whistle valve **(2)**, and oiler **(4)**. See the topic, PRESSURE REGULATING VALVE, BALANCED WHISTLE VALVE, AND OILER.
3. Install a ½″ - 13 (NC) eyebolt as shown in illustration.
4. Attach a suitable hoist and remove the bolts **(3)**.

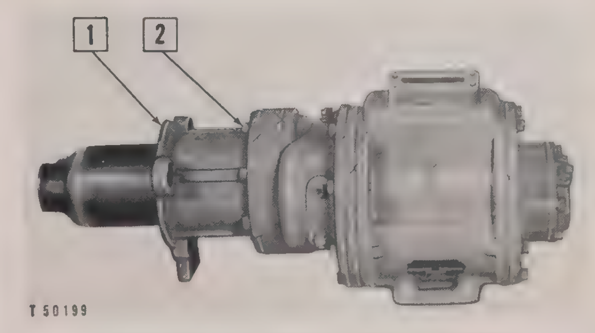


REMOVING AIR STARTING MOTOR

5. Remove the air starting motor as illustrated.
6. Inspect all parts for wear or damage and replace if necessary.

Disassembly

1. Mark the mating parts as shown.

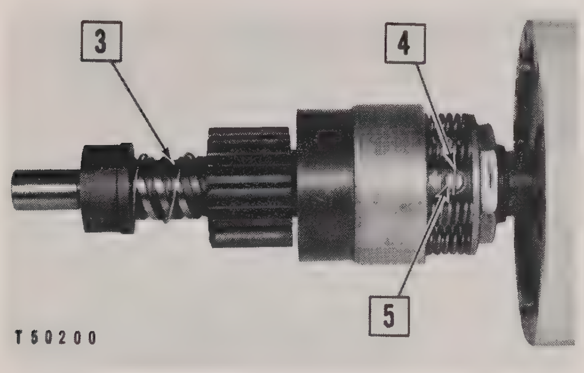


PREPARING TO REMOVE DRIVE HOUSING

☐ **Remove**

1–Drive housing. 2–Bolts (eight).

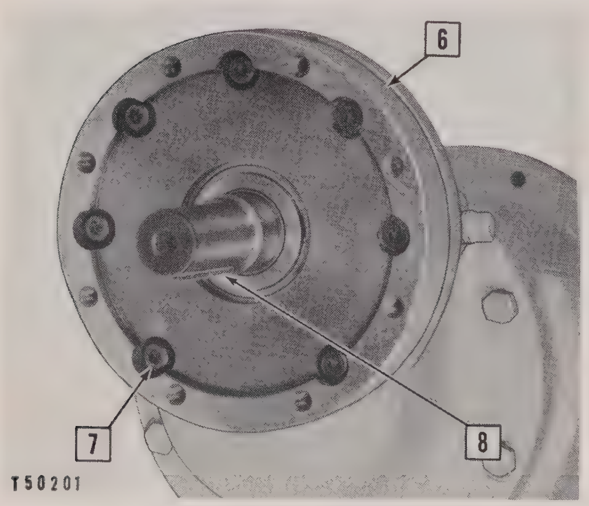
2. Remove the cover which is located over the end of the shaft **(16)**.



REMOVING DRIVE

☐ Remove

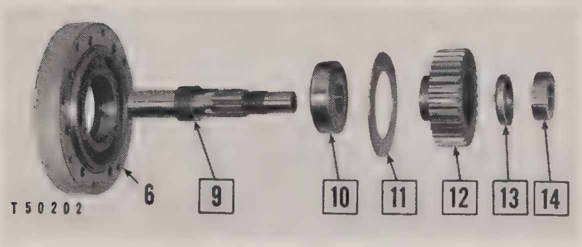
3–Drive. 4–Ring. 5–Screw.



REMOVING COVER

☐ Remove

6–Cover. 7–Bolt (seven). 8–Key (two).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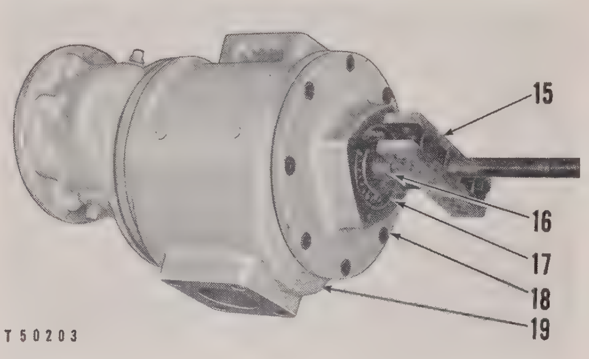
REMOVING SHAFT

☐ Remove

6–Cover. 9–Shaft. 10–Bearing. 11–Plate. 12–Gear. 13–Lockwasher. 14–Nut.

3. Remove the bolts which secure the plate **(18)** to the housing **(19)**.

4. Remove the plate **(18)** and the bearing **(17)** from the shaft **(15)** by using a 5F7465 Puller **(15)** and two ¼″ - 20 (NC) bolts 5″ long as shown.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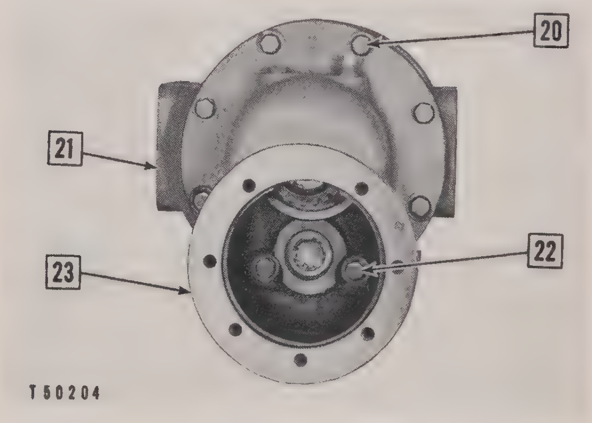
REMOVING PLATE
15–Puller. 16–Shaft. 17–Bearing. 18–Plate. 19–Housing.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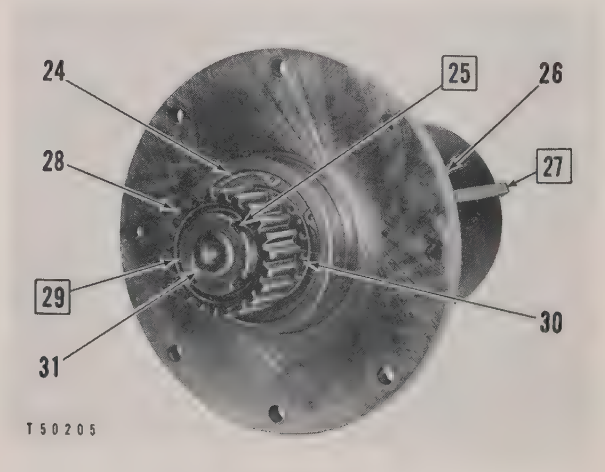
REMOVING HOUSING

☐ Remove

20–Bolts (eight). 21–Air motor housing. 22–Bolts (two). 23–Gear housing.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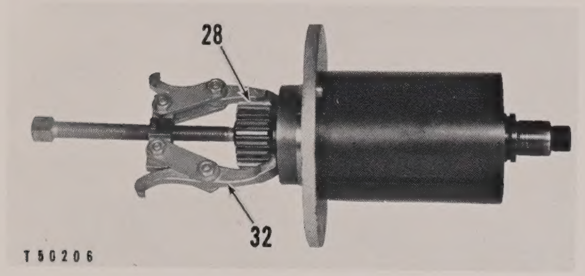
PREPARING TO REMOVE GEAR

☐ Remove

24–Snap ring. 25–Lockwasher. 26–Plate assembly. 27–Vane. 28–Gear. 29–Nut. 30–Bearing. 31–Shaft.

5. Remove the gear **(28)** from the shaft **(31)** by using an 8H695 Puller **(32)** as shown.



REMOVING GEAR
28–Gear. 32–Puller.

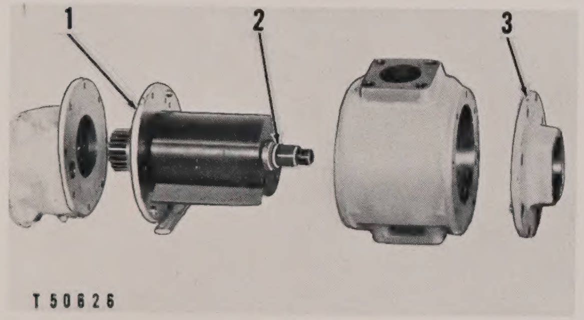
6. Remove the snap ring **(24)** and the bearing **(30)** from the plate assembly **(26)**.
7. Inspect all parts for wear or damage and replace if necessary.

Assembly

Inspect all parts for wear or damage and replace all the gaskets.

CAUTION

Carefully install the plates **(1)** and **(3)** on the rotor shaft, to avoid damaging the rings **(2)** which seal the ends of the rotor.



PREPARING TO ASSEMBLE AIR STARTING MOTOR
1–Plate. 2–Ring. 3–Plate.

Assemble in the reverse order of disassembly.

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